PERSPECTIVES ON THE DYNAMIC HUMAN-WALRUS RELATIONSHIP

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By

Martin D. Robards, B.Sc., M.Sc.

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By

Martin D. Robards

RECOMMENDED:

John J. Burns

John J. Burns

Alexander S. Kitaysky

A.L. Lovecraft

Amy L. Lovecraft

Peter P. Schweitzer, Advisory Committee Co-Chair

F. Stuart Chapin III

F. Stuart Chapin III, Advisory Committee Chair

Richard D. Boone

Richard D. Boone, Chair, Department of Biology and Wildlife

APPROVED:

Joan Braddock

Joan F. Braddock, Dean, College of Natural Science and Mathematics

Lawrence K Duffy

Lawrence K. Duffy, Dean of the Graduate School

August 4, 2008

Date

ABSTRACT

Changes in sea ice conditions have direct bearing on ice-associated species such as Pacific walrus (*Odobenus rosmarus divergens*), which are an important component of subsistence for Alaska Native communities in the Bering Sea. I explore the relationship between walrus, sea ice, and Alaska Native subsistence at Diomede, Gambell, and Savoonga between 1952 and 2004 to better understand walrus ecology and subsistence under different climatic regimes. I then consider how the inability to reliably and regularly count walrus and other ice-associated pinnipeds in this dynamic environment challenges effective management of walrus and subsistence under the Marine Mammal Protection Act (MMPA). However, the primary management goals of the MMPA, which are intended to be ecosystem-based, have been bypassed in favor of a numerical population assessment approach. Governance approaches such as adaptive co-management, using a suite of ecological and population indicators have theoretical promise for making management responsive to both observed ecosystem and population changes. Nevertheless, understanding outcomes of co-management has proven difficult. To address this, I argue that such an understanding requires not only a review of a statute's ecosystem-oriented goals, but also a critical consideration of the specific goals of each co-management partner. To sustain natural resources, mismatches between the scale of ecological processes regulating resources, and the social or political processes governing resource use should logically be reduced, thus improving what is termed "fit." I argue that failures to foster fit of these processes might better reflect underlying co-management partner goals, rather than a focus on the statutory goals of policy. I examine this claim by assessing the spatial and temporal "fit" of boundaries defining the political context of walrus co-management under the MMPA. I find that the ability to address the uncertainty of walrus population status in a manner benefiting adaptation of both walrus and

Alaska Natives to a dynamic environment is compromised by a focus on values, rather than better matching policy with ecological and social conditions. My interdisciplinary findings are broadly applicable to community-based conservation partners seeking to foster resilience and adaptation of both natural resources and of the indigenous or rural communities dependent on them.

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I thank the people who gave me perspective on the world, most closely my family; Barry Daniel who taught me to contemplate and explore the world; Patricia Gaines who taught me to explore inward; Mike and Phyllis Balough who met me on shorelines; Vera Metcalf, Chris Perkins, and Charles Brower who met me at cultural borders; Kathleen Osowski who taught me that time does not wait; Amy Lewis for listening, understanding, and being the light when all was dark; Chanda Meek for both broadening and temporally bounding my learning; Annette Watson for questioning what learning is; Stacia Backensto for a Gemini twin's perspective; Dipani Sutaria for dreaming of new system states; and to all my friends who have both inspired and humbled me; the community of the Resilience and Adaptation Program, and the 2005 Circumpolar Arctic Social Sciences group; the communities of Gambell and Savoonga, particularly the families of the Koonookas and Kingeekuks; the Eskimo Walrus Commission; Julie Lurman Joly and Joshua Greenberg for invaluable insights on legalistic and economic perspectives on the world; Josh Wisniewski for keeping a perspective on communities and hunters; Jillian Grayson, Helene Marsh, and Donna Kwan for reminding me there's a world of other perspectives. I thank the U.S. National Park Service's Beringia Program, particularly Peter Richter and Katya Wessels for funding much of this work; the ARLIS library staff, particularly Sharon Prien for help with reference materials; Brad Benter and Mike Wade of U.S. Fish and Wildlife Service, Gay Sheffield of the Alaska Department of Fish and Game, and Todd O'Hara of UAF for their camaraderie and support; Ryan and Karen McLane for great hospitality and friendship; and to my committee – Amy, John, Peter, Sasha, and Terry who demonstrated patience, tenacity, and a wealth of insight.

INTRODUCTION

Problems

Problems can't be solved with the mind set that created them.

Albert Einstein

Perspective

a: the interrelation in which a subject or its parts are mentally viewed <places the issues in proper *perspective*>; *also* **:** point of view b**:** the capacity to view things in their true relations or relative importance <urge you to maintain your *perspective* and to view your own task in a larger framework...>

Merriam-Webster

Finding Perspective

I have always felt that the action most worth watching is not at the center of things, but where edges meet. I like shorelines, weather fronts, and international borders. There are interesting frictions and incongruities in these places, and often, if you stand at the point of tangency, you can see both sides better than if you were in the middle of either one.

Ann Fadiman. The Spirit Catches You and You Fall Down

...read everything that has been written, said, or otherwise preserved on the topic of your research in the time period pertaining to your research. The injunction to read everything does not mean to read the existing theoretical literature, digest it, regurgitate it, use it to structure your research and then read what relates to it. No, unfortunately, it means read absolutely everything, ignore nothing that might reveal the lines that connect your object of study with every other thought or practice of its time. It means avoid isolation of your topic, which would lead merely to some normalizing statement about human or institutional behavior as, for example, revealing the universality of self-interest or altruism or self-preservation. Instead, the aim is to identify the linkages among bodies of knowledge, institutions, and practices prevalent in society at a particular time that converge on your research topic and reveal its singularity.

Brass (2000) drawing on Foucault's concept of the Archaeology of Knowledge.

The Relationship between Humans and their Environment

Philosophically science has long wrestled with the concept of humans as a part or separate from the ecosystems in which they exist. However, the linkages between man and environment have never been in doubt. George Perkins Marsh (1874) in *The Earth as Modified by Human Action* was clearly aware of the "action and reaction between humanity and the material world around it." Furthermore, he poignantly argued that the "collateral and unsought consequences of human action [were] often more momentous than the direct and desired results." Now 100 years later, with increasing awareness of the scale of human modification of the biosphere and further recognition of the unintended long-term consequences of short-term ecosystem modifications, there is a pressing need for science to provide better understanding of the dynamic relationships that exist between people and their environment.

Human communities around the world exist in a dynamic and reciprocal relationship with their particular environment and are in turn linked to those environments and people that spatially and temporally bound them (Ludwig et al., 2001; Tsing, 2005). These coupled human-environment systems are complex, respond to disturbances in a non-linear manner, are self organizing, and evolve through time (Levin, 1999; Gunderson and Holling, 2002; Folke, 2006). As such, responses to interventions or disturbances are not predictable or mechanistic; rather they are process-oriented and organic, with feedbacks at multiple temporal and spatial scales leading to emergent properties (Levin, 1999; Folke, 2006). In addition to their inherent dynamics, ecosystems may exist under alternate states, some concurrently and others not (Beisner et al., 2003). While alteration of one component of a system at one scale may be buffered by other components present in a specific state or scale, feedbacks and synergies among components and scales may lead to transformation. Transitions between states are characterized by hysteretic effects and path dependence (Perrings, 1998). These facets of human-environment connectivity are axiomatic, irrespective of wilderness, rural, or urban designation.

The field of resilience has developed to address the need for a better theoretical understanding of the non-linear dynamics inherent in ecosystems, including those used and modified by humans. In many senses, a resilience-oriented way of thinking provides a theoretical grounding to the complexities inherent in Aldo Leopold's "land ethic" (Leopold, 1949; Norton, 1988). Resilience is the capacity of a system to absorb disturbance to some variable and still retain its organizational structure and essentially the same functions, identity, and feedbacks (Walker et al., 2004). Social resilience has been defined a little differently, but still retains the same intent: "the ability of groups or communities to cope with external stresses and disturbances as a result of social, political and environmental change" (Adger, 2000).

In this dissertation, I address the desire to foster the resilience of common-pool resources (CPRs) in a rapidly changing environment. CPRs represent those resources where, once resource units are removed from the pool, they are no longer available to the commons; and exclusion of beneficiaries through physical or institutional means is either impossible or especially costly (Ostrom et al., 1999). Resilience helps provide a deeper understanding of the inherent tradeoffs and challenges to both people and resources associated with favoring specific human-environment relationships (Folke et al., 2004; Liu et al., 2007). In particular, a focus on one scale leads to tradeoffs with other spatial and temporal scales, which has been central to the sustainability debate (e.g., Robards and Greenberg, 2007).

The basic strategy to managing CPRs is to limit resource use in the interest of long-term sustainability (Acheson, 2006). Property rights must be effectively implemented to eliminate open-access and resource-users must agree to rules curbing exploitation rates. Institutional failure occurs when one or both problems remain unsolved (Acheson, 2006) or the management context changes with no learning or adaption to the new conditions. Failing to establish rules to guide resource use risks what Hardin (1968) called the "Tragedy of the Commons." However, although Hardin advocated privatization and centralized controls of resources as a solution (Hobbe's Leviathan), numerous studies indicate collective action by resource users can successfully result in rules of restraint (Dietz et al., 2003). Hardin's thesis is more one of a "tragedy of free access" than one purely of the commons.

Through politics, stakeholders collectively negotiate what an appropriate relationship between resources and their users should be and how that relationship should be managed in a dynamic environment. Seeking to find political economy and potentially greater equity in resource management, environmental governance has developed as a "set of regulatory processes, mechanisms and organizations through which political actors influence environmental actions and outcomes" (Agrawal, 2005; Lemos and Agrawal, 2006; Armitage, 2008; Kooiman et al., 2005). Adaptive co-management has developed as a form of environmental governance fostering collaborative and adaptive approaches to sustained use of resources, while supporting social-ecological resilience (Armitage, 2008). The approach is premised on production of a political structure that fosters resilient relationships between people and their environment.

Governance structures such as adaptive co-management have promise for enabling governments and resource users to achieve mutually-beneficial natural resource management goals. However, although we have long known of the dynamics that humans share with their environments, wrestled with the appropriate relationship between different people, and between people and their environment, our understanding of how to manage pluralistic interactions or alter subjectivities toward mutually beneficial outcomes remains elusive. In particular, the polarized protectionist versus conservationist debates of the John Muir and Gifford Pinchot era of the early 1900s remain problematic in many co-management projects involving indigenous subsistence.

The pluralism of such projects necessitates what Søreng (2006; drawing on Jürgen Habermas) regard as "moral discourses" that support the legitimacy of actions across cultures. Søreng's conclusions mirror a trend toward a greater focus on the *processes* inherent in resource governance, rather than a focus on the frequently value-laden *outcomes* (Norton and Steinemann, 2001).

My particular research investigates the resilience of pluralistic relationships between people and resources, what Langdon (2003) terms "relational sustainability." I focus on the political and ecological context in which governance currently takes place for the human-walrus (*Odobenus rosmarus divergens*) relationship in the Bering Strait region. As I demonstrate, the processes of governance for marine mammals such as walrus epitomize the protectionist versus conservation debate. I demonstrate how dynamic ecosystem changes conspire with incompatible and incommensurable use of values to shape interpretations of policy that are unresponsive to either the needs of species like walrus or of Alaska Native communities. Like Tsing (2005: xi), I recognize that the spaces shared by government and indigenous resource users in co-management represent "zones of awkward engagement where words mean something different across a divide, even where people agree to speak." Therefore, to understand the actual role of policy in balancing conservation, or even preservation of walrus, while supporting Alaska Native subsistence, as well as the application of science in this dynamic environment, requires attention to the power of different parties to shape the meaning of science or policy over time (Bryant, 1998; Armitage, 2008).

The Human-Walrus Relationship in the Northern Bering Sea

The ancestors of the current villages in the northern Bering Sea originated from around 2200 – 1500 BP. In the approximately 2000 years of existence until present, Iñupiaq and Yupik cultures adapted to numerous environmental and social challenges, developing many innovations as they became proficient marine mammal hunters. However, in 1966 anthropologists were "writing an obituary" for the hunting-and-gathering societies of the world, including the Eskimo of Gambell on St. Lawrence Island. Nevertheless, only 40 years later, the Anthropologist Marshall Sahlins (1999) celebrated that the "Eskimo are still there – and still Eskimo," but asks "how did the Eskimo do that?" Jorgensen (1990: 6) concludes that there has been a "determination on the part of the Eskimos to maintain traditional Eskimo culture and at the same time to adopt a pragmatic acceptance of the benefits of modern technology." Clearly the Eskimo have both remained resilient, but to some extent transformed, while maintaining an identity as Eskimo.

Interestingly, not only humans have succeeded to sustain themselves beyond expectations in the Bering Strait region. At the end of the 19th century walrus were diminished to the point where they were thought to face possible extinction (Allen 1880; Lucas 1891) and were again assessed to be in dire straits in the late 1950s (Fay, 1982). The reduced walrus herds of the late 1950s thus coincided with the pessimism for continued cultural survival of the communities that relied on them. The sustained presence of both walrus and communities today lends further support to understanding how the relationship between walrus and people has emerged through time, and what the process was that produced the outcome of 'co-existence'.

Scope of Dissertation

The overarching question that this dissertation addresses is "what are the effects of a changing climate on the human-walrus relationship?" To address this question, I divide the dissertation into three parts. First I explore the relationship between walrus, sea ice, and Alaska Native subsistence between 1952 and 2004 to better understand walrus ecology and subsistence under different climatic regimes. In particular, I consider how the location of communities within the northern Bering Sea is at the edges of both cultures and ecosystems, which is thought to increase their flexibility and resilience to change (Turner et al., 2003).

Second, I consider the ability of policy to adapt to this changing environment. In particular, I focus why the inability to reliably and regularly count walrus and other ice-associated pinnipeds in this dynamic environment presents significant challenges for effective management under the Marine Mammal Protection Act (MMPA). However, the primary management goals of the MMPA, which are intended to be ecosystem-based, have been bypassed in favor of a more conventional numerical population assessment approach. Governance approaches such as adaptive co-management, using a suite of ecological and population indicators have theoretical promise for making management responsive to observed ecosystem and population changes. Nevertheless, walrus co-management does not currently foster such an approach.

To address why walrus co-management is not responsive to a changing environment, I use the third and final part of this dissertation to assess the political space of walrus co-management. I argue that to understand this space requires not only a review of a statute's ecosystem-oriented goals, but also a critical consideration of the specific goals of each co-management partner. To sustain natural resources such as walrus, mismatches between the scale of ecological processes regulating resources, and the social or political processes governing resource use should logically be reduced, thus improving what is termed "fit." Failures to foster fit of these processes might better reflect underlying partner goals, rather than statutory goals of policy. I examine this claim by assessing the spatial and temporal "fit" of boundaries defining the political context of walrus co-management under the MMPA. I find that the ability of co-management to address the uncertainty of walrus population status in a manner benefiting adaptation of both walrus and Alaska Natives is compromised by a focus on values. I therefore build from previous work (Robards and Joly, 2008), and explore how Policy could be better matched to the dynamic ecological and social conditions of the northern Bering Sea in a manner reducing the current suite of unintended consequences from a mismatched policy interpretation.

Bounding of Research

My work is bounded temporally and spatially. Temporally I use 1952 as a starting point based on the availability of historical data, my premise of using Sahlins' observation that many anthropologists perceived the Eskimo as doomed at that time, and Fay's similarly pessimistic perspective on the Pacific walrus population. I recognize profound social changes prior to 1952, including arrival of the Yankee whalers, famine, disease, WWII, and what Hughes (1960) called the "irrevocable effects" of loss of food independence. Ecologically, my time period of interest is preceded by what is thought to be a consistently low walrus population between the decimation of walrus herds by Yankee whalers in the mid 1800s to the end of commercial harvesting in the early 1900s. Politically, the period immediately preceding my investigation hosted few political interventions directly relevant to walrus subsistence (excluding the temporary wartime move of Gambell in 1942).

Spatially, I focus on the area from St. Lawrence to Diomede in the northern Bering Sea, this area encompassing the communities most reliant on walrus during the past 50 years – Diomede (Inaliq), Gambell (Sivuqaq), and Savoonga (Sivungaq). Between 1952 and 2004, the region has experienced profound change in physical conditions such as climate and sea ice (ACIA, 2005), in the abundance of walrus (Fay et al., 1997), in social conditions (Jorgensen, 1990), and in the political system of governance, particularly Alaska statehood in 1958 and the transition to federal management under the MMPA in 1972.

Caveats to the Research and Data Collection

The goal of this research is to compile some of the many disparate aspects of the human-walrus ecosystem into cogent interdisciplinary scientific frameworks that address the impacts of climate change on the human-walrus relationship. The historical record from the past 50 years, although largely unpublished in agency reports, researcher and missionary diaries, and archived data, contains a considerable quantity of local and scientific observations of people, walrus, the Bering and Chukchi sea environment, and regional politics. This dissertation has sought to develop knowledge from the collected historical data, what Michael Foucault refers to as "archaeology of knowledge." Then with the newfound knowledge and mindset, I have hoped to share perspectives and provide insights for communities and managers as they move ahead, facing old and new problems in a continuingly unpredictable environment.

The goal of this research is not to develop new ethnographies for the northern Bering Sea region. The goal is to view objectively the inter-related dynamics of the region. Using a single place of observation from within the social and ecological milieu constrained an objective perspective. While others have made the commitment to a single place in this region (see for example the works of Linda Ellana and Conrad Oozeva), in seeking perspectives, I sought the edges between policy and culture, between academic disciplines and institutions. It was the frictions and incongruities that pervaded these places that informed this dissertation.

Despite not professing an ethnographic approach, I have committed to trying to read everything, and experiencing as much as possible of walrus hunting, management, and policy in this region. I used this experience to provide context for the historical records that described the human-walrus relationship. Prior to finalizing this dissertation, I completed a legal discourse analysis of what is meant by "wasteful manner" within the MMPA (Robards and Joly, 2008). This project in particular, allowed me to share perspectives on walrus management with hunters, law enforcement personnel, agency and co-management representatives, lawyers, and the U.S. Department of Justice. That experience was particularly valuable as I developed the legal discourses in Chapter 3.

I worked for the Eskimo Walrus Commission (EWC) as an intern and then as a biomonitoring specialist from November 2004 until 2008, attending most meetings of the full commission, of their executive board, and several closed executive sessions. I heard concerns and observations of life and politics in the region and had the opportunity to present my own findings. I presented research for discussion at hunter meetings on St. Lawrence Island during spring 2007 and 2008. I also lived on Saint Lawrence Island in the communities of Gambell and Savoonga during the spring of 2007 and 2008. Here, I was made welcome as I helped with projects collecting biological samples and monitoring harvests. In 2007, I travelled to Anadyr in Chukotka to share the results presented here in Chapter 1 with Russian researchers and community members who are addressing similar issues and concerns. I am indebted to the communities of St. Lawrence Island; Vera Metcalf, Chris Perkins, and Charles Brower of the Eskimo Walrus Commission; and Peter Richter and Katya Wessels of the National Park Service Beringia Program for making these interactions possible.

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CHAPTER 1

Spatial and Temporal Dynamics of the Spring Pacific Walrus Migration and Alaska Native Subsistence Hunt: 1952 – 2004[1]

[1]Robards, M.D., J.J. Burns, A.S. Kitaysky, and F.S. Chapin III. Spatial and temporal dynamics of the spring Pacific walrus migration and Alaska Native subsistence hunt: 1952-2004.

Spatial and Temporal Dynamics of the Spring Pacific Walrus Migration and Alaska Native Subsistence Hunt: 1952 – 2004

Abstract

Ongoing changes in the Arctic climate have resulted in a general decline in both the availability and vitality of sea-ice in the Bering Sea. Changes in sea-ice conditions have direct bearing on ice-associated species such as Pacific walrus (*Odobenus rosmarus divergens*), which are an important component of subsistence for the region's Alaska Native communities. I explore the relationship between walrus, sea-ice, and subsistence hunting between 1952 and 2004 to better understand walrus ecology and the dynamics of walrus subsistence. I integrate changes in timing, size, and the gender distribution of the walrus harvest; existing information on climatically-forced ecosystem regime shifts; and agency reporting and local perspectives on these changes. In doing so, I gain insights on how the timing and demographics of walrus migration patterns are affected by climate regimes. I find markedly different magnitudes and degrees of variability in success and timing of spring walrus hunts at Diomede, Gambell, and Savoonga. My results suggest local ice conditions, along with socio-political factors, promote strong inter-annual variability in the timing and size of walrus harvests at all villages. However, longer-term climatic regimes are correlated with parallel changes in patterns of timing and magnitude of harvests at Gambell and Savoonga, and at Diomede until 1989. I attribute social changes as the primary cause of the more recent reduction in size of harvest at Diomede. Nevertheless, deterioration of sea-ice conditions has reduced the window of hunting at Diomede as walrus migrate more quickly between St. Lawrence Island and the Bering Strait. At the same time, deterioration of sea-ice has improved Savoonga's access to walrus. Large-scale sea-ice studies do not include the finer-scale social processes of adaptation that are critical for differentiating how different villages face different challenges in order to safely and successfully hunt walrus.

Introduction

Significant difficulties persist in applying broad-scale observations of climate-change impacts on marine ecosystems to the local scale of both wildlife populations and human communities (Laidler, 2006; Gearheard et al., 2006). Contributing to this difficulty, ecosystems are both spatially heterogeneous and temporally dynamic. Therefore, relationships within these ecosystems, including those relationships between people and natural resources, change over space and time (Holling, 1986; Hughes et al., 2005; Liu et al., 2007). Specific environmental conditions favor specific human-environment relationships in specific locations and at specific times. To assess impacts of environmental change on human–resource relationships at the village level requires attention to choices of both spatial and temporal scales of analysis as well as the interactions across scales. Taking such an approach is well described for resource relationships in fisheries, for example, but is less well described with respect to subsistence activities in arctic and subarctic environments (Krupnik and Bogoslovskaya, 1999; Duerden, 2004).

The northern Bering Sea (Figure 1-1) hosts a highly productive marine ecosystem between Chukotka (Russia) and Alaska (United States; Springer et al., 1996; Grebmeier et al., 2006). The region is ice-covered in winter, but in spring and summer sea-ice retreats north through the Bering Strait into the Chukchi Sea and Arctic Basin. In conjunction with the annual spring retreat, populations of marine mammals migrate through the northern Bering Sea and in turn have supported numerous Native villages in Alaska and Chukotka (Krupnik and Ray, 2007). Native subsistence harvest of marine mammals has now taken place in the Bering Sea for over 2000 years. Villages have gained distinct advantages from living at ecological and cultural edges due to the inherent diversity and connections of the Beringian region, which benefits their resilience to environmental and social change (Krupnik, 1993; Turner et al., 2003; Meek et al., *in press*). Nevertheless, Alaskan hunters are currently reporting broad-scale changes in sea-ice and weather patterns that reduce their ability to safely and efficiently find, access, retrieve, and return walrus to communities (Metcalf and Robards, 2008). For example, Patrick Omiak Sr. of Diomede states that "the ice always gone so fast that we are not catching walrus like we used to"; Leonard Apangalook of Gambell states "our walrus season is very short now" (Eskimo Walrus Commission, 2003); and Conrad Oozeva of Gambell (in Oozeva et al., 2004) states that "because the ice melted too fast, the walruses moved faster and in shorter time than usual."

The Northern Bering Sea's subarctic climate is characterized by both large interannual variability, and decadal-scale changes in two dominant climate patterns: the Pacific Decadal Oscillation (PDO) and Arctic Oscillation (AO; Stabeno and Hunt, 2002). The climatic patterns impact the extent and quality of sea-ice in the Bering Sea. Recent decadal-scale climatic change has resulted in both a general decline in the extent and quality of sea-ice in the marginal ice zone of the Bering Sea, more open water, earlier break up, and later arrival of the fall pack ice (Huntington, 2000; Grebemeier et al., 2006; ACIA, 2005; Stabeno et al., 2007). Benson and Trites (2002) suggest that climatic forcing such as this indirectly affects marine mammal species through changes in the distribution and abundance of prey. However, subsistence species such as Pacific walrus (*Odobenus rosmarus divergens*) are an ice-associated marine mammal, using ice for a platform for resting, giving birth, and nursing (Burns, 1970; Fay, 1982; Fay et al., 1984). Consequently, their ecology is likely to change in concert with alterations in the extent and quality of their sea-ice habitat, and not just their prey. However, the precise relationships between sea-ice dynamics, walrus ecology, and the role they play in the northern Bering Sea ecosystem and Native subsistence are not well known (Ray et al., 2006).

Initial studies of the relationship between climate and sea mammal harvests in the Bering Sea were made by Krupnik and Bogoslovskaya (1999). They found that climatic factors that altered sea-ice and weather dynamics led to profound decadal-scale variation in the relative success of village marine mammal hunting. During the relatively warm period of the 1930s and 1940s, communities on the northern coast of Chukotka (Figure 1-1) generally retrieved greater numbers of marine mammals, while those in southern regions retrieved relatively few; in subsequent cooler conditions, this condition was reversed (Krupnik and Bogoslovskaya, 1999). Reciprocal ecological regimes of this kind represent long-term cycles, resulting from connections between climate, sea-ice, weather, and species within those ecosystems (Tynan and DeMaster, 1997; Wyllie-Echeverria and Wooster, 1998; Benson and Trites, 2002). Ecosystems and Native cultures of the Bering Sea region have adapted to inter-annual and cyclic variability of this type during the course of their existence. However, in this manuscript I address the questions that Native hunters and scientists are now raising about how communities will adapt to persistent or directional change, the type of change increasingly reported for the northern Bering Sea (Stabeno and Overland, 2001; Chapin et al., 2006; Grebmeier et al., 2006), and how the success of the spring hunt will change over time.

I expect that a better understanding of local-scale repercussions to human communities from a changing Arctic environment will be achieved by sharing perspectives from local observations and broad-scale scientific perspectives on climate change (Gearheard et al., 2006; Laidler, 2006; Krupnik and Ray, 2007; Metcalf and Robards, 2008). I focus on the northern Bering Sea region (Figure 1-1), including the Alaska Native villages of Diomede (Inaliq), Gambell (Sivuqaq), and Savoonga (Sivungaq), which have been the primary walrus hunting villages in Alaska over the past 60 years.

Background and Hypotheses

Four main factors are generally acknowledged to affect the magnitude and timing of walrus harvests in the northern Bering Sea: (1) walrus ecology; (2) sea-ice conditions; (3) weather; and (4) the social and technological setting of walrus hunting (Hughes, 1960; Fay, 1982;

Stoker, 1983). Some also attribute the political boundary with Russia as a constraining factor in hunting range for some villages, although practical evidence for this is mixed. In this manuscript, I focus on the first two of these factors, the relationship between walrus ecology and sea-ice conditions as evidenced by spring hunting success and timing at Alaska Native villages. I am particularly interested in learning whether climatic regimes are imparting directionality to the size of harvest and timing of season. Krupnik and Bogoslovskaya's (1999) study demonstrated the impact of changing climatic regimes on marine mammal harvests in Chukotka. Here, I test for the effect of climatic regimes on the size and timing of walrus harvests in Alaska. I hypothesize that climatic regimes will correlate with timing and success of harvests, and that shifts between regimes will be reflected in parallel changes among villages. Alternatively, where patterns in timing and size of harvests diverge among villages, I hypothesize that differences reflect village-specific sea-ice, weather, or social conditions.

Walrus Ecology

The use of sea-ice by walrus is balanced between finding ice of suitable thickness to support their weight while out of the water (>0.6 m), and ice that provides opportunities for passage while swimming, either so they can break through from beneath or have enough natural openings such as leads (<0.2 m; Fay, 1982). In the late winter and spring, walrus congregate in areas of unconsolidated pack ice, which usually occurs within 100 km of the leading edge of the pack ice (Burns, 1970; Gilbert, 1999). Consequently, although some walrus remain relatively far north in open leads throughout the winter, most overwinter south of St. Lawrence Island, only moving north during the spring recession of sea-ice (Fay, 1982). Sea-ice characteristics in winter lead to two major concentrations: one southwest of St. Lawrence Island and into the Gulf of Anadyr, and one in northern Bristol Bay delineated by differing types of sea-ice (Fay, 1982; Krupnik and Ray, 2007).

The northerly spring migration of walrus from wintering areas coincides with favorable ice movements during the retreat of ice through the northern Bering Sea (Figure 1-2). Walrus travel north with the ice, but are not restricted to passively riding on it; in fact the principle progress in migration may be accomplished by swimming as far north as ice conditions will permit (Burns, 1965; Fay, 1982). The northward drift of pack ice in spring during the 1930s brought walrus past St. Lawrence in May and June, and past Diomede into the Chukchi Sea in the early part of June (Collins, 1940; Oozeva et al., 2004). Heinrich (1947) documented the gender-segregated migration of walrus past Diomede, with females and calves preceding males. Gambell hunters have also long reported two phases of migration north past their village during May and June (Eskimo Walrus Commission, 2003; Krupnik and Ray, 2007).

Although the distribution of walrus, and thus their proximity to villages, is critical to the ability of a village to hunt walrus, abundance of walrus is obviously a contributing factor to success. In the 1870s, when the walrus population had been decimated by whalers, hunting even in core areas became difficult (Bockstoce 1986). Nevertheless, although the absolute size of the walrus population is thought to have varied markedly during the past 50 years and is currently unknown (Figure 1-3A), the proximity of the entire walrus population to the villages of my study, based on expected population sizes (i.e., it has not been as minimal as in the late 1800s) probably minimizes the effects of absolute population size on timing or size of the harvest.

Climate Change and Sea-ice

Despite the predicted scenarios of much-reduced or complete loss of summer sea-ice in the Arctic basin, sea-ice is predicted to continue forming over much of the Bering Sea during winter (ACIA, 2005; Lindsay and Zhang, 2005; Overpeck et al., 2005). Consequently, during spring, sea-ice will continue to annually recede north through the Bering and Chukchi seas into the Arctic Basin. Presuming that the winter sea-ice north of Bering Strait is not extremely broken allowing year-round access for large numbers of walrus into the Chukchi and East Siberian seas, sea-ice will continue to first preclude, and then as it retreats, provide access for walrus and other marine mammals to the productive areas north of the Bering Strait.

The major regime shifts that altered sea-ice extent and concentration in 1947, 1977, 1989, and 1998 are now well described by oceanographers and marine ecologists and summarized below (Benson and Trites, 2002; Hunt et al., 2002; Stabeno et al., 2007; Table 1-1). Prior to 1977 a ''cold regime'' (Stabeno et al., 2001) supported increasingly heavy ice conditions in the southeast Bering Sea, particular in the early 1970s which hosted more extensive ice than the two prior decades (Walsh and Johnson, 1979; Stabeno et al., 2007). After 1977, a "warm regime" dominated until 1989. Ice was reduced in extent and had lower concentration and shorter residence time; consequently, spring was earlier, with maximum ice extent occurring in March instead of April or May (Stabeno and Overland, 2001). Between 1989 and 1999 a ''cool period'' (Stabeno and Hunt, 2002) existed, although not to the extent of the early 1970s, in which ice persisted longer in the spring in the southeastern Bering Sea than in the 1980s. Sea-ice at this time was characterized by an extremely rapid melt-back in April leading to about a one-week earlier retreat of ice through the northern Bering Sea (Stabeno and Hunt, 2002). Since 1999, the timing of the spring ice retreat has been highly variable (Stabeno and Overland, 2001; Stabeno et al., 2007). While sea-ice now extends farther south, it has continued to retreat earlier and more rapidly than was common between 1989 and 1999, resulting in the northern Bering Sea being ice-free earlier than in previous decades (Stabeno and Hunt, 2002; Stabeno et al., 2007). Nevertheless, retreat of ice over the northern shelf has been highly variable, with ice persisting longer in 2001 than was common in 1989–1999 (Stabeno et al., 2007). The decrease in ice concentration is most noticeable in the southern region, but the effects continue north along the eastern Bering Sea into the Chirikov Basin. Eastern Bering Sea-ice concentration is decreasing faster than in the central and western Bering Sea (Stabeno et al., 2007).

Alaska Native Subsistence

The social and technological setting of walrus hunting has changed in many ways since 1952. For example, the increasing use of snow machines during the 1960s reduced the number of dogs that were needed for transportation on St. Lawrence Island. The reduction in dogs reduced the amount of walrus meat needed to feed them (Robards and Joly, 2008). However, despite social changes, the walrus harvest has retained its importance in the subsistence economy and diet (Stoker 1983; Metcalf and Robards, 2008).

Environmental factors govern the presence of and access to walrus for village hunters and are thus critical to success of the spring hunt (Stoker, 1983). However, the capacity of villages to hunt in different conditions has changed over time. Village populations on St. Lawrence Island have steadily increased over the study period (Figure 1-3B). Coupled with more numerous and faster boats (introduced in the 1970s), and better weapons (originally introduced in the 1800s), Gambell and Savoonga have steadily increased their capacity to hunt walrus (Robards and Joly, 2008). In contrast, Diomede has not increased in population (Figure 1-3B), has fewer young hunters, and uses fewer boats; thus their capacity to hunt may have actually declined relative to that of Gambell and Savoonga on St. Lawrence Island.

The most active walrus hunting period in the Bering Straits area is late spring, when the sea-ice is breaking up and the walrus herds are migrating north with the retreating ice edge (Fay, 1982; Burns et al., 1964). The speed of ice melt (thinning) and retreat (reduction in extent) affect the ability of hunters to reach, hunt, and retrieve walrus. In heavy ice conditions, walrus may still migrate past villages, while hunters are precluded from accessing the open leads and thin ice that the walrus are using. Conversely, thin ice may also be problematic: Leonard Apassingok Sr.

reports in the 2008 spring hunter meetings the prevalence of walrus going "past [Gambell] very quick, even when ice was there" describing the ice as "flimsy" and unsuitable for hunting.

Methods

I divide my analysis of the timing and success of the spring walrus hunt into the periods delineated by the 1947, 1977, 1989, and 1998 regime shifts in the Bering Sea as described by Benson and Trites (2002), Hunt et al. (2002), and Stabeno et al. (2007).

<u>Walrus Catch Data</u>

Total harvest numbers for each village were reported in Appendix 1 of Garlich-Miller et al., (2006). I use total numbers for adults from that dataset (1960-2002) and extend it with information as available between 1952 and 1959, and 2003 and 2004 from agency reports for those years.

Walrus harvest records for Alaskan villages between 1992 and 2005 were assembled by U.S. Fish and Wildlife Service and the Eskimo Walrus Commission (EWC). The USFWS Walrus Harvest Monitoring Program (WHMP) record gender and age-class for every walrus retrieved during the spring hunt. Monitors meet most returning boats from walrus hunts; therefore, numbers of unrecorded walrus are thought to be relatively small (Garlich-Miller and Burn, 1999). For data prior to 1992, I accessed data archived by prior agency researchers involved in similar harvest-monitoring programs: the late Bud Fay (1952-1975) archived with Brendan Kelly, John Burns (1958-1978), Kae Lourie (1980-1984), Scott Schliebe (1980-1989), and the Eskimo Walrus Commission. Sease (1986) compiled much of this information for animals of known age, although I use a more comprehensive dataset that includes all walrus known to be older than calves (but not necessarily of known age). I omit calves from my analysis as they are irregularly reported in harvest reports. Although walrus may be found and harvested at other times of the year, I focus specifically on the spring migration north, limiting my data to the 3-month period between April 1st and June 30th. I recognize reporting inconsistencies in harvest monitoring programs and the limitations of such programs (Robards et al., *submitted*), but assume that the proportion of unreported animals in a season is relatively consistent across a season. My primary interest is in chronology of the season which is less susceptible to biases in absolute numbers.

I calculated a value for timing based on mean date of the spring walrus harvest for each year and at each village based on the methodology of Sease (1986). Mean date is the sum of the number of walrus caught on each day multiplied by Julian date (based on January 1 = Julian day 1) divided by number of walrus harvested. Differences in timing of male and female walrus at villages were examined by Student t-test. For multiple comparisons of timing, I used ANOVA. A post-hoc Tukey's test for pair wise differences was used for significant ANOVA results to isolate environmental regimes and villages that differed in timing of harvests.

In order to address my overarching question of how climatic regimes affect the success of walrus harvests, I examine four sub-questions: (1) do spring walrus harvests differ among villages; (2) do spring walrus harvests differ among regimes; (3) does the timing of the spring hunt affect harvests; and (4) do the effects of village, regime, and timing of harvest interact? Statistically, these questions were evaluated with analysis of covariance (ANCOVA). I first tested for normality of the dependent variable (harvest). Finding that raw harvest data failed normality, I $\log_{10}$ transformed the harvest data to accomplish normality. The ANCOVAs included village and regime as factors and timing as a covariate. ANCOVA first tests for an interaction between factors and covariate (test for parallelism of slopes), and then evaluates an effect of categorical factors and linear effects of the covariate on the dependent variable.

Results

Of the total harvest of walrus reported for 1952-2004, size of harvest was available for 49 of 53 years for the villages of Diomede, Gambell, and Savoonga (no data were available for 1959, 1978, 1990, or 1991). In addition, I was able to recover daily-resolution harvest data for gender-specified adult walrus at Diomede, Gambell, and Savoonga for 34, 39, and 33, years, respectively; and for unsexed adults for 36, 40, and 34 years, respectively. Overall, my database of daily dates of harvest for known-sex adult walrus at Diomede, Gambell, and Savoonga represented 83%, 83%, and 94%, respectively, of the known harvest; and for all adult walrus (not differentiating gender) represented 84%, 87%, and 94%, respectively, of the known harvest.

Below, I present results for the Native villages of Diomede, Gambell, and Savoonga delineated by the four ecosystem regimes described above. I divide my results based on (1) timing of the spring walrus harvest among villages and between regimes; and (2) success of the spring walrus harvest among villages and between regimes. Finally, I address known influences of weather and social factors.

Timing of the Spring Walrus Harvest among Villages and between Regimes

Overall the mean timing of the hunt for females preceded that of males at both Diomede by 5.5 days (Paired t-test; $p < 0.01$, N = 25) and Gambell by 2.3 days (Paired t-test; $p = 0.02$, N = 34). The timing of harvest for males and females at Savoonga did not differ (Paired t-test; $p = 0.97$, N = 26). Differences in timing between sexes remained significant for all regime periods at Diomede, but only for the two middle two regime periods at Gambell (Paired t-test; $p < 0.05$). Differences between sexes of less than a week were much less than the overall variability within a regime (Figure 1-4); I therefore grouped sexes for comparisons between regimes and villages.

For a specific village, timing of walrus harvest at Savoonga was earlier in Regime 4 than in the first two regimes (one-way ANOVA, $p < 0.05$; post-hoc Tukey test, $P < 0.05$). Timing showed no statistical difference at Diomede or Gambell for all regimes (one-way ANOVA, p =0.27).

Comparing between villages, Gambell and Savoonga were both significantly earlier in timing than Diomede in Regime 1 (one-way ANOVA, $p < 0.01$; post-hoc Tukey test, $p < 0.01$), but did not differ from each other (post-hoc Tukey test, $p = 0.09$ and 0.78, respectively). However, in the cold heavy ice conditions at the end of Regime 1, Savoonga harvests were almost a month later than a decade earlier. All three villages significantly differed from each other in timing during Regime 2 (one-way ANOVA, $p < 0.01$; post-hoc Tukey test, $p < 0.01$). In the warmer Regime 3, only Diomede differed from Gambell in timing (one-way ANOVA, $p = 0.02$; post-hoc Tukey test, $p < 0.05$). Savoonga's timing was not significantly different from that for Diomede or Gambell (Tukey test, $p = 0.38$, 0.19, respectively). In the most recent regime, Gambell and Savoonga were both significantly earlier in timing than Diomede (one-way ANOVA, $p < 0.01$; post-hoc Tukey test, $p < 0.01$); in particular, Savoonga harvests advanced in timing by nearly 6 weeks compared to where they had been in the early 1970s.

The Gambell hunting season was the most consistently timed of the three villages, the long-term average date of the hunt being May 18th (SD = 9.6 days, N = 13,298 adult walrus). Overall, the long-term average timing at Savoonga was 5 days later on May 23rd (SD = 13.7 days, N = 10,667 adult walrus). Finally, Diomede, although exhibiting significant trends in timing during more recent regimes was in the long-term, only a little more variable than Gambell, although about two weeks later, with a long-term average harvest date of June 4 (SD = 10.2 days, N = 10,114 adult walrus).

Close examination of harvest timing suggests strong directional change, with timing getting earlier at Diomede and Savoonga during regime 3, followed by a rapid delay in timing at the transition to regime 4 in 1998. Heavy pack ice during the spring of 1998 did not allow

Savoonga hunters to launch boats for most of that season, both reducing harvests (Garlich-Miller et al., 2006) and delaying timing. However, from 1998 until 2004, a return in harvest success and a continued directional trend of advance in timing of the spring hunt at all three villages resumed (Figure 1-4).

I used the difference between mean harvest dates of males and females at St. Lawrence Island compared to Diomede as a proxy for the speed of the migration through the Chirikov Basin (Figure 1-1). Although there was no significant overall trend, my data suggested a consistently earlier timing for the female migration over time, but a shortening of the time taken by males (of about 3 days) to pass between the two islands (Figure 1-5). During Regime 3, timing of the walrus harvest at Diomede and Savoonga also became 3 weeks earlier, suggesting a much quicker rate of migration during that period, coinciding with more rapid ice retreat through the northern Bering Sea (Table 1-1).

In an effort to avoid bias from occasional catches of single walrus prior to the main spring season of walrus hunting, I delineated a window of the spring hunt based on the first and last day on which at least 5 walrus were returned to a village (Table 1-2). Diomede generally had the shortest season and Savoonga the longest season of the 3 villages (Table 1-2). The shorter spring hunting season for Diomede during Regimes 3 and 4 were accompanied by only half the days on which more than 5 walrus were harvested compared to Gambell and Savoonga (Table 1-2).

Size of the Spring Walrus Harvest among Villages and between Regimes

The size of the walrus harvest in the different villages has varied markedly between years and between regimes, including when controlling for different human populations in villages (Figure 1-6; Table 1-3). ANCOVA results indicated significant differences between mean harvests among regimes, but not among villages; models including regime having the strongest effect compared to those including village or timing (Table 1-4). Harvests rose to their maximum during Regime 2 (Figure 1-7). Subsequently, harvests declined, although declines in harvests at Diomede were much more pronounced than for Gambell and Savoonga. In Regime 4, harvests for Gambell and Savoonga both increased, while Diomede diverged from what had been a parallel pattern among villages, continuing to host decreasing walrus harvests (Figure 1-7)

Within-cell regression for my ANCOVA analysis suggested no linear effect of timing on the size of harvest across the four regimes combined ($F = 1.16$, $p = 0.28$; Table 1-4). However, although the relationship between timing and harvest success was parallel among villages ($F = 1.43$, $p = 0.24$), the signs of this relationship were different among regimes ($F = 4.60$, $p = <0.01$). I investigated this more closely by plotting regressions of season timing versus harvest for the four regimes (Figure 1-8). In Regime 1, cold conditions and heavy ice led to more productive harvests during years when the spring hunt extended later into May and June. In the warmer conditions of Regime 2, harvests were generally high and were less dependent on timing. This pattern changed in the cooling conditions of Regime 3. However, during Regime 3 later harvests contrasted to those in Regime 1 by hosting lower, as opposed to higher harvests. I attribute this to more rapid ice recession, which limits hunting opportunities during the late season. Finally, in the variable conditions of Regime 4, harvests at Diomede and Savoonga, like in Regime 2 were less dependent on timing, whereas Gambell's harvests continued to benefit in extended seasons. I attribute this to the ability of Gambell hunters to hunt in a wide array of conditions, so later seasons provide opportunities for a greater number of successful days (Table 1-2).

<u>Hunting Behavior versus Climate Variability</u>

The interannual variability in the timing and size of the spring walrus harvest at Diomede, Gambell, and Savoonga reflect the dynamic ecosystem and social conditions in which hunting takes place. Although the broad patterns I describe here correlate with climatic regimes and known walrus ecology, I strongly emphasize the contribution of social factors. Diomede in particular, during the latter two regimes has been subject to a suite of societal changes including human tragedies: shifts in demographics such as an aging population, emigration of young hunters, and loss of critical mass for effective village hunting; enforcement issues; technological loss of skin boats due to lack of skin splitters, which restricts hunting range and acceptable hunting conditions; and reduced economic reliance on ivory carving.

Social preferences for specific components of the walrus population also bias our data. Gambell hunters preferentially harvest female walrus and calves, whereas Diomede hunters have historically focused on male walrus. Preferential harvest of a specific gender can delay the focus on the other. For example, the late harvest of males at Gambell in 1987 was attributable to an extended period when females were present. Subsequently, as females continued moving north, and away from Gambell, males were delayed in arriving due to a late break-up of ice to the east of St. Lawrence Island. This shows up as an outlier in my data lending credence to this methodology being sensitive to non-climatic factors. Also at Gambell, there have been increasing tensions concerning local rules protecting the preceding Bowhead (*Balaena mysticetus*) whaling season. Whaling requires quieter tactics and until recently utilized skin boats moving under sail, compared to walrus hunting in motorized aluminum skiffs. Local rules have usually divided the whale and walrus hunting seasons at about the last week of April or first of May. In years when walrus appear early, they may not be hunted, or if they are, by fewer hunters if whaling is not finished (Sease, 1986; USFWS, 2005). This factor may have limited the advance of the Gambell season in my data by reducing walrus harvests in April.

Weather conditions also have a strong effect in some seasons. Wind in particular, may be the "decisive" factor in the ability to hunt on a particular day, pushing ice onshore preventing access to walrus or offshore taking walrus too far away (e.g., Hughes, 1960; Fay, 1982). For example, in 1968, south winds in spring pushed the sea-ice far out from Savoonga and Northeast Cape on St. Lawrence Island, with the result that Savoonga's harvest in spring was only 57 walrus in contrast to 455 for the same period in 1966 (Burns, 1969). Wind may also conspire with sea-ice, such as in the late 1940s when it exacerbated heavy ice conditions that subsequently led to food shortages and "distress" in communities of the region (Hughes, 1960). Conversely, the late harvests in Savoonga in 1995 were attributable to wind keeping ice close to Savoonga much later than normal, providing an extended period of access to walrus.

Discussion

Variation in Season of Village Harvests

Despite the profound changes reported in climate in the northern Bering Sea, seasonality of walrus harvest patterns by gender and season have remained remarkably consistent at Gambell (Figure 1-4), suggesting a consistent timing of walrus migration past that village since the 1930s (Collins, 1940; Heinrich, 1947). Strong currents through the Gulf of Anadyr create and maintain open leads around Gambell. Hunters also have greater flexibility than the other villages, with easy access from both a western and north-facing facing beach, providing a variety of conditions in which ice doesn't block access to walrus. Further north, Diomede also has high currents and strong winds that open leads even in dense ice that can allow limited but productive hunting. However, Diomede hunters frequently report ice conditions that preclude access from the village, even when walrus are present. Variability of ice conditions is likely greater at the Bering Strait due to the effects of the substantial constriction on ice movements north and helps explain the rapid changes in timing at Diomede during the past two regimes (Figure 1-4). For example, the timing of the 1998 regime shift coincided with a 2 to 3-week change in timing of the Diomede hunt, confirming local hunter concerns about the great variability of walrus hunting conditions at this village. Savoonga hunting was the most variable in timing overall. Savoonga faces north and is susceptible to the frequent north winds that compact ice along the northern shore of St. Lawrence Island, precluding hunting directly from the village. Timing of the harvest at Savoonga was about 5 weeks earlier in 2004 compared to the early 1970s at the end of the "cold regime" (the only significant change in timing of harvest that I found at a specific village; Figure 1-4). Deterioration of ice has allowed walrus to migrate closer to this village and hunters to access them earlier between 1998 and 2004.

Walrus are thought to remain as far north as they can during the spring, based on sea-ice conditions (Burns, 1970). Consequently, in recent years, thinner ice conditions would be expected to allow walrus to move further north in late winter and early spring than in prior colder regimes. However, timing of harvest at Gambell on St. Lawrence Island did not significantly alter between 1952 and 2004. In contrast, the significantly earlier season at Savoonga to the east of Gambell on St. Lawrence Island, suggests that the historic passage of walrus north past St. Lawrence Island was more restricted on the east and north sides. An earlier amelioration of sea-ice conditions in spring now provides access for Savoonga hunters to male walrus that historically passed later through Shpanberg Strait (Fay, 1982). Although my results were not statistically significant, they suggest a quicker passage of males through the Chirikov Basin supporting my contention of quicker passage north past Savoonga (Figure 1-5). Ice concentrations are also reported as decreasing most in the eastern Bering Sea (Stabeno et al., 2007), further supporting a quicker passage of males through this area. Nevertheless, once past St. Lawrence Island, the female passage ahead of males has remained, at least until 2004, as a consistent signature of the Pacific walrus spring migration by the time herds reach Diomede.

Variation in Size of Village Harvests

The size of the walrus harvest has been reported elsewhere, although usually with respect to biological removals, rather than village's capacity to hunt (Fay et al., 1997; Garlich-Miller et al., 2006). Garlich-Miller et al. (2006) conclude that interannual variability in harvest size may be attributable to the variable spring hunting conditions. Overall, harvests at all three villages peaked in the middle of Regime 2. This period not only coincided with a warming of climatic conditions and reduced extent and quality of sea-ice, but also with growing size of village populations (Figure 1-3B), and introduction of aluminum boats on St. Lawrence Island; the period was also thought to represent maximal numbers in the Pacific walrus population (Figure 1-3A). The very high per-capita rates of harvest at Diomede suggest much better access to walrus at that site during this period. The last two regimes during the 1990s and 2000s have supported significantly lower harvests at Diomede, although this is most likely a consequence of profound social change.

Harvests of walrus may be regarded as an emergent property of the complex system that makes up the human-walrus subsistence relationship. Although interannual variability in harvests is high, the long-term per-capita stability of the harvest (apart from the 1980s) is surprising (Table 1-3). Apart from during Regime 2, when harvests were particularly high at Diomede, and to a lesser extent Gambell, the per-capita harvest rate has been relatively consistently between 0.6 – 0.9 walrus per person per year. Per-capita harvest has remained relatively stable, despite an increased capacity to harvest walrus on St. Lawrence Island due to technology and numbers of hunting crews taking part in the harvest during recent years (Robards and Joly, 2008). I suggest two environmental and two social hypotheses to explain this harvest stability. First, in environmental terms, conditions for hunting walrus have declined in parallel with the increased capacity to hunt; alternatively, the walrus population may have declined enough to hinder subsistence. Second, in social terms, per-capita demand for walrus may not have increased despite improved technology and more hunters; alternatively, informal institutions may have restrained harvest despite increased harvest capacity. Hunters have not raised concerns about a reduced population (Eskimo Walrus Commission, 2003), and the social hypotheses are beyond the scope of this manuscript. Below I discuss climatic conditions as a control over walrus harvest.

Implications to Pacific Walrus Ecology

Ray et al. (2006) highlight the importance of walrus feeding on the re-suspension of benthic sediments and the consequent role walrus have in increasing primary productivity. If walrus move as far north as possible based on sea-ice conditions (Burns, 1970), changes in distribution due to ameliorating ice conditions, or time spent feeding in the northern Bering Sea may alter these patterns.

Historically, migration of walrus was generally in gender-segregated groups, with females preceding the passage of males. With more rapid passage of male walrus, this pattern may begin to deteriorate, which is corroborated by hunter observations of unusual mixed-gender herds (Metcalf and Robards, 2008). However, the implications of increasingly mixed-gender herds of walrus are beyond the scope of this research.

Implications to Communities

The timing and size of harvests present communities with two challenges. First, timing alters the window of the hunt, and for places like Gambell, changes in timing of one subsistence harvest can end up conflicting with other harvests such as whaling. Second, the size of harvests caters to the economic and sustenance needs of communities, and shortfalls require substitution of other resources or sources of income.

As elsewhere Arctic subsistence hunters demonstrate a significant ability to adapt to the challenges presented by changing climatic conditions on timing and size of harvests (Ford et al., 2008). Adaptability is facilitated by local knowledge, continued learning, strong social networks, flexibility in resource use, and institutional support (Metcalf and Robards, 2008; Ford et al., 2008). Currently Gambell appears the best located of the villages for continued successful hunting of walrus because strong winds and currents provide consistent hunter access to migrating animals in most years. Diomede hunters report a shorter season in recent years, have much reduced capacity to hunt based on number of hunters compared to Gambell and Savoonga, and in recent regimes have only had half as many successful walrus hunting days (those days where > 5 walrus are returned). The trend of increasing speed of passage of walrus between St. Lawrence Island and Diomede substantiates Diomede hunter concerns about shorter hunting seasons, but I emphasize the importance of social considerations that conspire with these difficult environmental conditions to reduce the current capacity of Diomede to hunt walrus. Savoonga, in contrast has maintained a relatively consistent level of harvest despite profound changes in timing of season. Nevertheless, a quicker walrus hunting season conspires with other factors such as weather and economic costs of hunting, exacerbating local concerns about the future implications to their economy, life-style, and cultural traditions. Historically, hunters rarely travelled more than 40 km from villages. Hunters in faster motor-powered boats on St. Lawrence Island now travel great distances to find walrus when seasons get shorter, greatly increasing the economic costs of hunting.

The advantages of living on cultural and ecological edges such as in the Bering Strait have been profound through time, supporting the notion that this gives a "greater capacity for flexibility" that increases social-ecological resilience (Turner et al. 2003: 439). All three villages have adapted to profound interannual variability; however, my results suggest differing responses to the more persistent change associated with regime shifts. As the juncture between winter and summer becomes shorter, Gambell may be the least vulnerable of the three villages to changes in the northern Bering Sea ecosystem. However, Savoonga may benefit from the new suite of conditions that leave it less vulnerable to the consequences of heavy ice, although hunters may need to travel further to catch the same number of walrus in a shorter season. Diomede may be the most vulnerable to environmental change due to profound social changes, a much smaller village, fewer hunters, and being subjected to more rapidly migrating walrus and variable ice conditions. These factors conspire to shorten the effective window of hunting at Diomede. In all cases, the ability of communities to adapt and remain resilient in the face of profound environmental change will continue to be meditated by the social milieu in which subsistence takes place. In particular, hunters living a subsistence lifestyle will continue to be "engaged in a life long personal search for ecological understanding..." in order to remain resilient to a profoundly changing environment (Battiste and Henderson, 2000).

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Table 1-1. General characteristics of sea-ice during the four environmental regimes that are widely recognized by oceanographers and marine ecologists for the period 1952 to 2004. Regime shifts were in 1947, 1977, 1989, and 1998 (Benson and Trites, 2002; Hunt et al., 2002; Stabeno et al., 2007).

Regime	Conditions
Regime 1: 1947-1976	"Cold" with heavy ice conditions
Regime 2: 1977-1988	"Warm" with sea-ice reduced in extent, of lower concentration, and shorter residence time in the Bering Sea
Regime 3: 1989-1997	"Cool" with rapid retreat of sea-ice leading to a one week earlier passage through the northern Bering Sea
Regime 4: 1998-2004	"Variable" with generally, an early and rapid retreat of sea-ice

Table 1-2. Mean window (days between first and last day when >5 walrus were returned to a village), and mean number of days when >5 walrus were returned during a season to the villages of Diomede, Gambell, and Savoonga. Periods represent the four ecological regimes in the Bering Sea region that are widely recognized by oceanographers and marine ecologists between 1952 and 2004 (Benson and Trites, 2002; Hunt et al., 2002; Stabeno et al., 2007).*

	1952-1976		1977-1988		1989-1997		1998-2004	
	Window	Days >5	Window	Days >5	Window	Days >5	Window	Days >5
Diomede	21	10	27	11	17	6	22	5
Gambell	24	6	29	14	35	11	28	13
Savoonga	32	12	41	9	34	10	29	12

*I present harvest data in context of the environmental regimes. However, I strongly emphasize that correlations in the data should be treated cautiously. Profound effects of social factors undoubtedly contribute to the observed patterns.

Table 1-3. Human populations, mean walrus harvest, and per-capita rate of harvest (number of walrus per inhabitant) for the villages Diomede, Gambell, and Savoonga during the four environmental regimes that are widely recognized by oceanographers and marine ecologists for the Bering Sea region since 1952 (Benson and Trites, 2002; Hunt et al., 2002; Stabeno et al., 2007)*

	Diomede			Gambell			Savoonga		
Regime	Population	Harvest	Rate	Population	Harvest	Rate	Population	Harvest	Rate
1	88	397	4.5	358	223	0.6	304	271	0.9
2	139	660	4.7	445	654	1.5	491	414	0.8
3	178	147	0.8	525	328	0.6	519	230	0.4
4	146	94	0.6	649	476	0.7	643	367	0.6

*I present harvest data in context of the environmental regimes. However, I strongly emphasize that correlations in the data should be treated cautiously. Profound effects of social factors undoubtedly contribute to the observed patterns.

Table 1-4. Results of the analysis of covariance on the effects of village and regime on harvest of Pacific walrus in the spring hunt at Diomede, Gambell, and Savoonga, with timing of the hunt as the covariate.

Source	*df*	*MS*	*F*	*p*
Regime	3, 98	0.74	9.88	<0.01
Village x Regime	6, 98	0.56	7.50	<0.01
Village	2, 98	0.39	5.20	0.07
Regime x Timing	3,95	0.31	4.60	<0.01
Village x Regime x Timing	11,87	0.11	1.50	0.15
Village x Timing	2,96	0.11	1.43	0.24
Timing	1,98	0.11	1.43	0.28

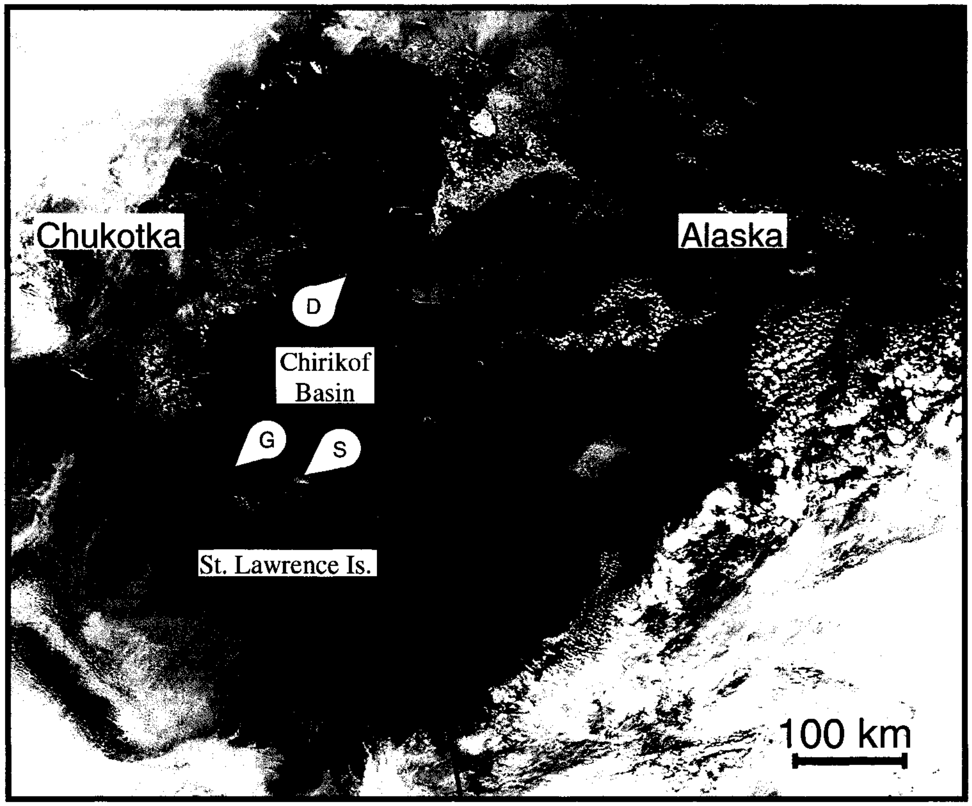

Figure 1-1. The northern Bering Sea region showing locations for the villages of Gambell (G) and Savoonga (S) on St. Lawrence Island, and Diomede (D). The 168.5 degree meridian is shown passing to the east of St. Lawrence Island and through Bering Strait.

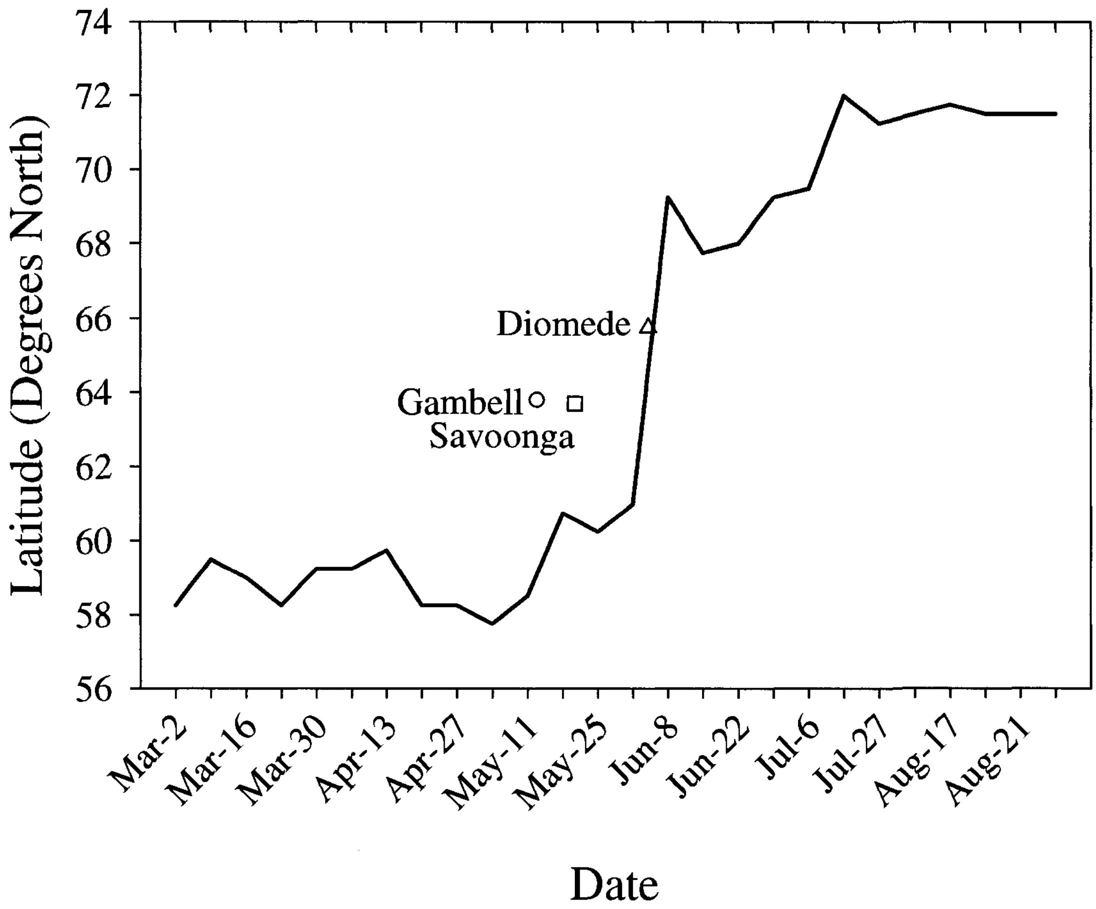

Figure 1-2. Typical spring ice dynamics of the maximum extent of the 30 percent sea-ice concentration along the Meridian 168.5° W as observed in 1982. Mean harvest date for the Alaska Native villages of Diomede, Gambell, and Savoonga are shown.

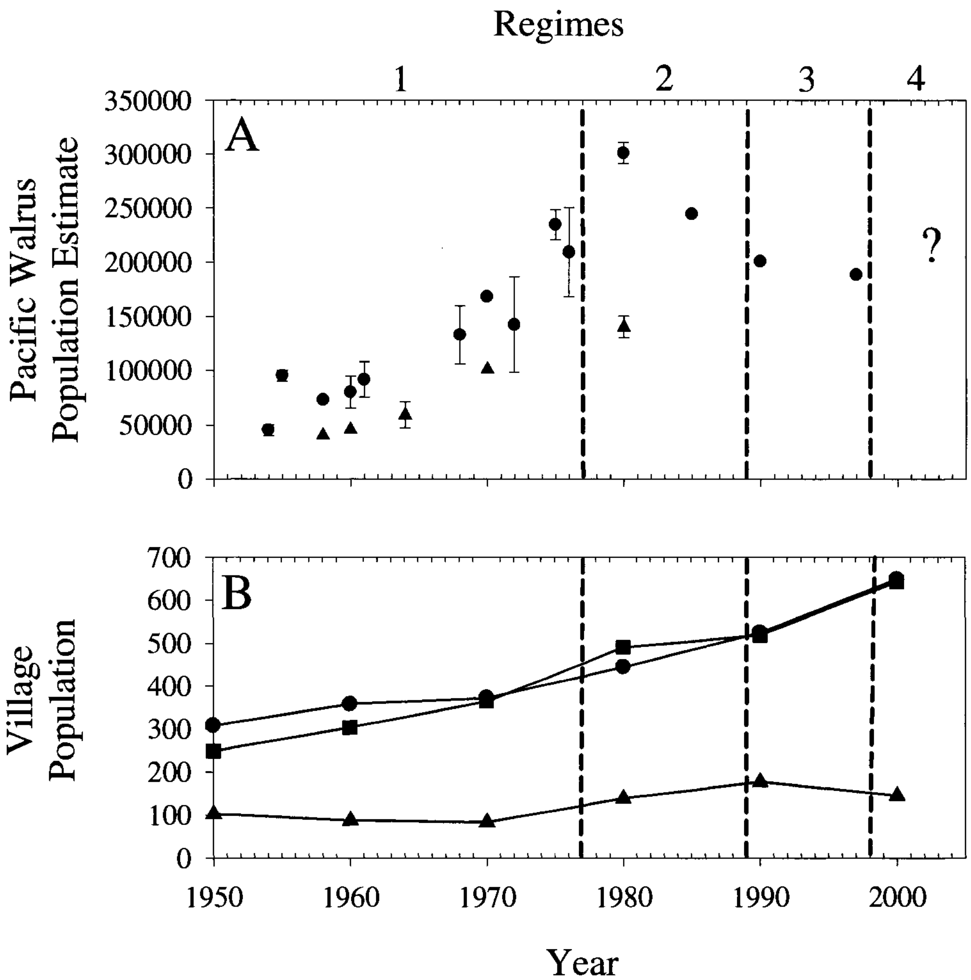

Figure 1-3. Historical pattern of two contextual factors (walrus and human population) governing subsistence hunting of walrus. Vertical dashed lines represent boundaries between environmental regimes that are widely recognized for the Bering Sea region by oceanographers and marine ecologists for the period 1952-2004 (Benson and Trites, 2002; Hunt et al., 2002; Stabeno et al., 2007). (A) Estimates of the total (●) and Russian component (▲) of the Pacific walrus population; data from Fay et al., (1997). (B) Human population trends for the villages of Diomede (▲), Gambell (●), and Savoonga (■); data from Alaska Department of Commerce, Community, and Economic Development.

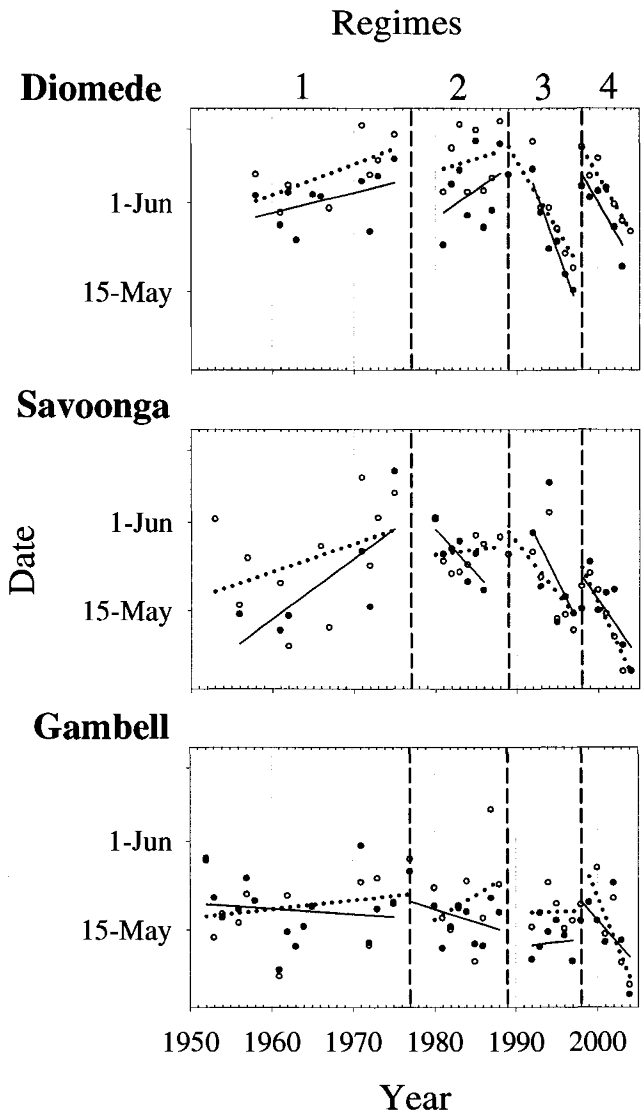

Figure 1-4. Mean harvest date for adult male (○) and female (●) walrus retrieved by the Alaska Native villages of Diomede, Gambell, and Savoonga between 1952 and 2004. General trends (lines-of-best-fit) are indicated for male (····) and female (—) walrus. Vertical dashed lines represent boundaries between environmental regimes that are widely recognized for the Bering Sea region by oceanographers and marine ecologists for the period 1952-2004 (Benson and Trites, 2002; Hunt et al., 2002; Stabeno et al., 2007).

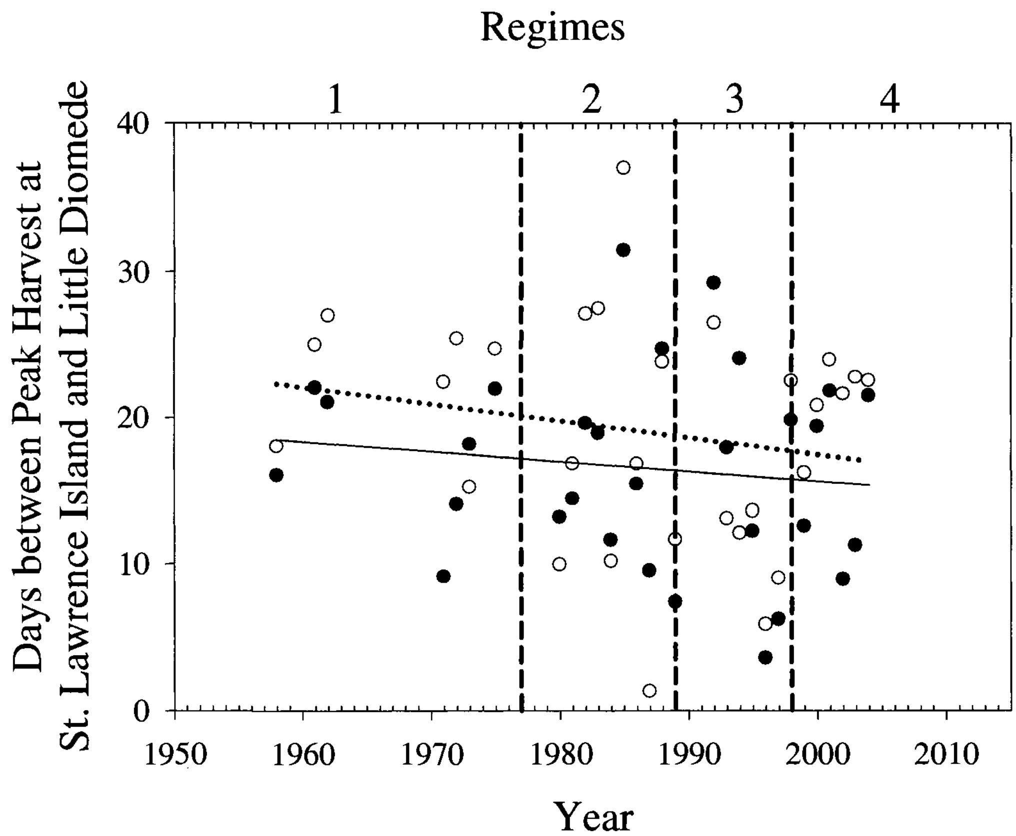

Figure 1-5. Duration between the mean dates of spring walrus hunting at St. Lawrence Island and Diomede for adult male (○) and female (●) walrus. Female walrus general transited the distance between St. Lawrence Island and Diomede more quickly than males, although timing has become closer in recent years. General trends (lines-of-best-fit) are indicated for male (····) and female (—) walrus. Vertical dashed lines represent boundaries between environmental regimes that are widely recognized for the Bering Sea region by oceanographers and marine ecologists for the period 1952-2004 (Benson and Trites, 2002; Hunt et al., 2002; Stabeno et al., 2007).

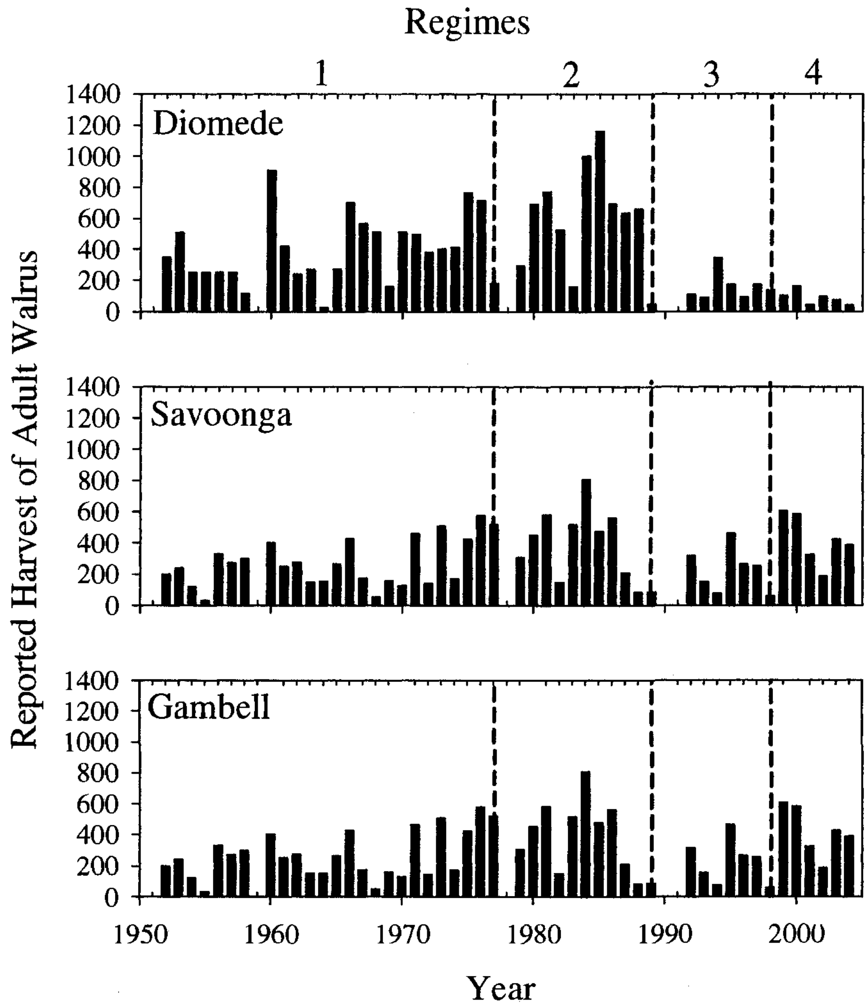

Figure 1-6. Historical pattern of reported harvest of walrus for the Native villages of Diomede, Gambell, and Savoonga. Vertical dashed lines represent boundaries between environmental regimes that are widely recognized for the Bering Sea region by oceanographers and marine ecologists for the period 1952-2004 (Benson and Trites, 2002; Hunt et al., 2002; Stabeno et al., 2007). No data were available for 1959, 1978, 1990, or 1991. I present harvest data in context of the environmental regimes. However, I strongly emphasize that correlations in the data should be treated cautiously. Profound effects of socio-political factors undoubtedly contribute to the observed patterns.

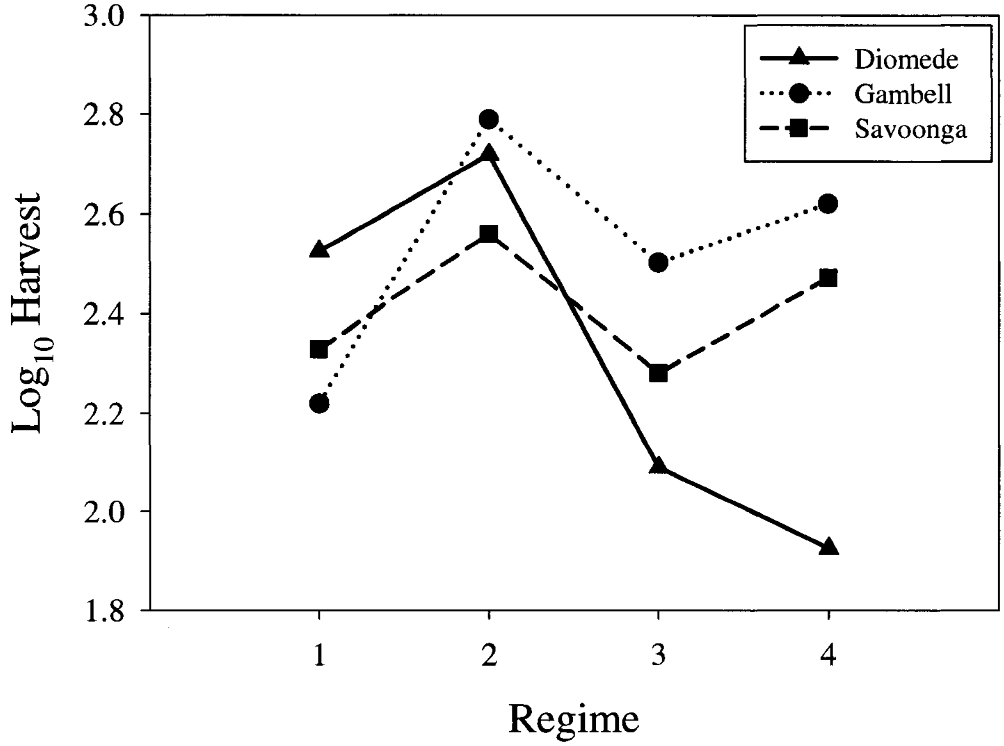

Figure 1-7. Mean harvest (log_{10} transformed) of Pacific walrus by subsistence hunters at Diomede, Gambell, and Savoonga during the four environmental regimes that are widely recognized for the Bering Sea region by oceanographers and marine ecologists for the period 1952-2004 (Benson and Trites, 2002; Hunt et al., 2002; Stabeno et al., 2007).

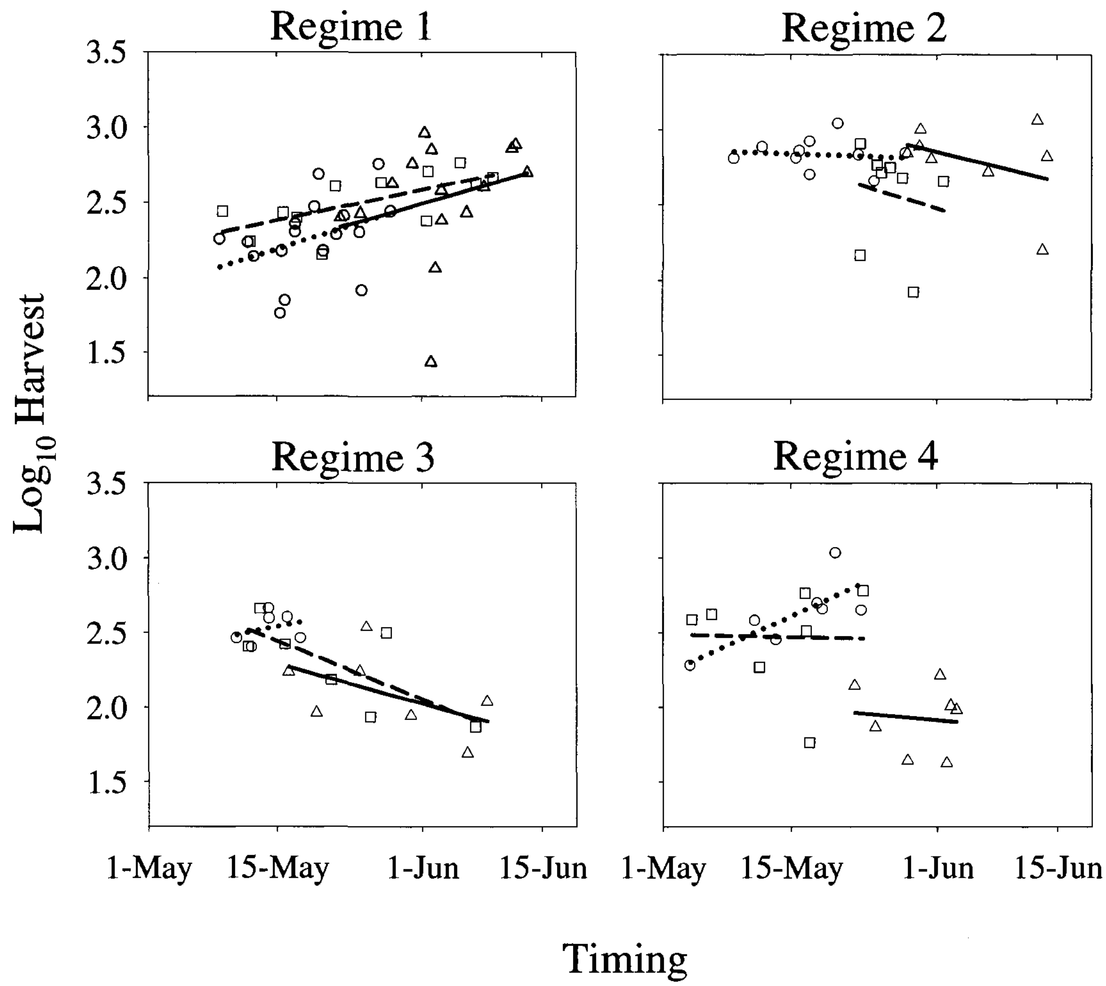

Figure 1-8. Relationship between harvest ($\log_{10}$ transformed) of Pacific walrus and mean timing of the spring walrus hunt at the villages of Diomede (△, —), Gambell (○, ····), and Savoonga (□, ----) during the four environmental regimes that are widely recognized for the Bering Sea region by oceanographers and marine ecologists for the period 1952-2004 (Benson and Trites, 2002; Hunt et al., 2002; Stabeno et al., 2007).

CHAPTER 2

Pacific Walrus Management: Considering the Value of Numbers in a Changing Environment[1]

[1]Robards, M.D., J.J. Burns., C.L. Meek., and A. Watson. Pacific Walrus Management: Considering the Value of Numbers in a Changing Environment

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Pacific Walrus Management: Considering the Value of Numbers in a Changing Environment

Abstract

The rapidly changing environment of the Beringian region and the inability to reliably and regularly count walrus and other ice-associated pinnipeds provide significant challenges for effective management of these species under current agency interpretations of the Marine Mammal Protection Act (MMPA). However, the primary management goals of the MMPA, which are intended to be ecosystem-based, have been bypassed in favor of a numerical population assessment approach. I revisit the statute's primary goals in light of current scientific evidence and new developments in environmental governance. My review suggests that, to proactively monitor and respond to expected changes in the walrus ecosystem, management should use scientific criteria that depend less on the necessity of detecting numerical depletion, than on precautionary actions based on known ecological needs and observed ecological changes. Even considering that carrying capacity is spatially and temporally transient, an "ecological indicators" approach, if decision rules can be developed, may better align immediate management needs with the best available scientific information. This approach might avoid the crises that have befallen several other marine mammal species, where populations were allowed to erode while waiting for legally defensible evidence of population depletion. The application of new approaches such as adaptive co-management, using a suite of ecological and population indicators, has theoretical promise for making management responsive to observed ecosystem and population changes.

Introduction

Estimates of stock abundance are a fundamental tool for managing wildlife populations (Caughley and Sinclair, 1994; Williams et al. 2002), despite the expense and challenges to achieving adequate accuracy and precision (Morellet et al., 2007). Unfortunately, population estimates alone, absent an understanding of the wider context in which populations fluctuate (e.g., density dependence or varying demographics), are largely a meaningless basis for understanding the health, status, or specific management needs of a wildlife population (Gordon et al., 2004; Ray and McCormick-Ray, 2004; Nichols and Williams, 2006). In this paper, I focus on the United States Marine Mammal Protection Act (MMPA), which mandates consideration of a marine mammal population's management within an ecosystem context.

In 1972, the MMPA established a general moratorium on take of marine mammals, responding to the tenuous circumstances of many of the world's marine mammal species and public outcry about both the high incidental take of dolphins in tuna fisheries and seal pup harvests in the North Atlantic. The MMPA provides several exceptions to the moratorium, including one recognizing federal responsibility toward Alaska Native subsistence rights, permitting the non-wasteful take of non-depleted marine mammals such as walrus for subsistence and handicrafts. Other exemptions include those that allow a limited incidental take to accommodate industrial activities such as commercial fishing or oil and gas exploration. Thus, establishing if a species is depleted, which is assessed within the context of carrying capacity, or accounting for appropriate levels of 'take,' are fundamental goals of the MMPA.

Determination of carrying capacity has remained a persistently challenging task under the MMPA, leading to a general reliance on population abundance estimates for assessing a marine mammal population's status. Assessment of carrying capacity is problematic due to the non-equilibrium dynamics of ecosystems (Marsh et al., 2004; Morellet et al., 2007), especially where ecosystems are changing in a manner that leads to alternate ecosystem states, termed regime shifts (Benson and Trites, 2002). Furthermore, assuming environmental change is axiomatic, the numerical relationship between a population of a particular species, at a particular time and place, and their environment's carrying capacity will always be in flux. For policies or management that seek to maintain wildlife populations, or restore them to specific levels (including historical maxima), this transience in carrying capacity is highly problematic (Hilborn et al., 1995; Swetnam et al., 1999; Pitcher, 2005; Marsh et al., 2005).

Recently, Taylor et al. (2007) suggested that, for several species governed by the MMPA, not only is carrying capacity problematic, but assessing population trends may also not be achievable. In particular, a 50 percent decline in population size over a 15 year period could go undetected based on current survey techniques applied at 4-year intervals. Most difficult to assess were the pagophilic (ice-loving) pinnipeds, including the Pacific walrus (*Odobenus rosmarus divergens*) and four species of seal: bearded (*Erignathus barbatus*), ribbon (*Phoca fasciata*), ringed (*Phoca hispida*), and spotted (*Phoca largha*). These species comprise important ecological components of the Beringian region (the combined shelf areas of the Bering, Chukchi, East Siberian, and Beaufort seas) and represent major subsistence resources for the region's Native cultures (Krupnik and Ray, 2007).

In this manuscript I focus specifically on the Pacific walrus, summarizing current trends and predicted future scenarios for both the subarctic and Arctic environment and the walrus population. I then describe the primary ecosystem-based goal of the MMPA and discuss why the MMPA's secondary goal associated with numerical population status has generally been used as the basis for management. Reliance on numerical population assessment has resulted in the recognized decline of some marine mammal species beyond crisis points before interventions were initiated (e.g., walrus, Fay et al. 1989; Cook Inlet beluga, Moore and DeMaster, 2000; and

Steller sea lion, Mansfield and Haas, 2006). These interventions were divisive due to debate over validity of the observed population change and different interpretations and assessments of causality based on incomplete or non-existent data. Further indications that the MMPA policy is failing to learn or respond to contemporary conditions include (1) continued declines and listing of several species per provisions of the U.S. Endangered Species Act (ESA), (2) inability to establish quantitatively as depleted some of the most endangered marine mammal species (Lowry et al., 2007), and (3) lack of attention to ecosystem and habitat considerations except under crisis situations. The MMPA calls for the "best scientific information available." I therefore address these issues through a focus on new scientific insights and proactive ecosystem-based governance.

Pacific Walrus and their Changing Environment

Evidence from satellite data, field research, and Native communities' observations in the Beringian region over the past decade suggest profound alterations in sea ice as a result of a changing climate, including a shortened ice season, lower ice concentrations, and greater summer recession (ACIA, 2005; Grebmeier et al., 2006; Ray et al., 2006; Metcalf and Robards, 2008). Pacific walrus rely on ice for much of the year, so changes in ice affect walrus ecology. Ice is a platform for walrus during the winter for resting, feeding, and breeding. Subsequently, during spring and summer, walrus become increasingly gender/age segregated. Large numbers of females and calves normally stay with the ice, using it as a drifting platform on which they rest and nurse, and from which they feed as the ice cover seasonally contracts (although, some utilize terrestrial haulouts, particularly in the Western Bering and Chukchi seas). The majority of males remain south to feed from land during summer such as at Round Island in Alaska, rejoining females as the ice advances south during early winter (Fay, 1982).

Walrus rely on both sea-ice and land to rest, but use of these substrates differs in relation to feeding ecology. From ice, ocean currents carry walrus over new areas of benthos, limiting depletion in any one spot (Fay, 1982; Ray et al., 2006). In contrast, while foraging from land, walrus become central place foragers as they feed, and return to specific haulouts. Prey depletion around terrestrial haulouts may be significant and can lead to redistributions of walrus population components. Overall, Pacific walrus historically consumed up to an estimated 3 million metric tons of benthos per year; and in doing so, they re-suspend sediments, providing positive feedbacks to production through increased nutrient flux in the areas where they feed (Ray et al., 2006).

Recent climate change has profoundly impacted females and calves that travel north with the sea ice in summer. Walrus effectively feed in water depths up to about 110 m (Fay and Burns, 1988). Once sea ice retreats north past the shelf break into deep waters of the Arctic basin, walrus are progressively less able to feed themselves and their calves from ice and need to relocate to land to rest and feed until the ice advances again (similar challenges are predicted for Atlantic walrus; Derocher et al. 2004). In recent years, as sea-ice receded past the shelf break into the deep Arctic basin, both researchers and hunters noted poor condition of females at haulouts early in fall, and evidence of abandoned calves (Cooper et al., 2006; Metcalf and Robards, 2008). Nevertheless, walrus survived profound environmental change in the past, and a consistent summer redistribution of females and calves to land may be a realistic adaptive scenario for current and predicted environmental conditions. Recent increases in terrestrial haulout use in summer and fall in both northwest Alaska and Chukotka support this hypothesis (Personal Communication with Joel Garlich-Miller, U.S. Fish and Wildlife Service (USFWS) and Anatoly Kochnev, Chukotka TINRO; September 2007). With increasing use of terrestrial haulouts, females and especially calves are more vulnerable to a variety of mortality factors, including being crushed or severely injured in panic stampedes; predation by polar bears similarly driven to land (Kelly, 2001); by various human activities including aircraft overflights and hunting; and by localized prey depletion near frequently used haulouts.

In conjunction with reductions in summer sea ice and the potential for walrus redistribution, prey abundance for benthic feeders such as walrus may also be declining within the Beringian region. Grebmeier et al. (2006) offer two potentially complementary hypotheses for reductions in benthic biomass: first that predators such as walrus have exceeded the carrying capacity of their prey, and second that ecosystem changes have led to declines in benthic productivity. The first hypothesis remains untested, but existing evidence supports the latter (Bluhm and Gradinger, 2008). Both bottom-up and top-down hypotheses are problematic for calculating what constitutes a healthy walrus population based on current ecological conditions. In either case a population decline would be expected unless walrus are below or at the carrying capacity of their changing environment. I also expect that a specific spatial and temporal configuration of sea ice is required to maintain high walrus populations, deviations from which will also reduce the Beringian region's capacity to support walrus.

The persistence of recent changes in Beringia remains speculative, but continued deterioration of sea ice is a widely accepted future trend (e.g., ACIA, 2005; Grebmeier et al., 2006; Ray et al., 2006). This factor alone, presents great uncertainty about the future ecological characteristics of the Beringian ecosystem, how many walrus that ecosystem can support, how current levels of subsistence harvest affect the walrus population, or how these combined changes will impact Native subsistence.

Current Knowledge about the Size of the Pacific Walrus Population

The Pacific walrus population appeared to increase rapidly (approximately 9 % per year) during the 1960s and 1970s, rebounding as a result of a significant reduction in harvests (Fay et al., 1989). This was surprising for a reproductively K-selected species with a presumed annual rate of increase of 3 to 6 %, leading Ray and McCormick-Ray (2004) to hypothesize that "variable and imperfect methods" of surveys may have underestimated the original walrus population size, or overestimated the 1980 figure of about 300,000 animals. However, walrus recovery from profound exploitation at various times in the past indicates that the population is capable of recovery under some conditions. Furthermore, the increase into the 1980s led to perceptions that density-dependent mechanisms might cause the population to surpass carrying capacity (Fay et al., 1989). Since that time, although circumstantial evidence suggests some degree of population decline, the population trends in Beringia's walrus are unmeasured.

Since inception of the MMPA, biologists attempted to estimate the total Pacific walrus population in 1975, 1980, 1985, and 1990 using aerial survey techniques. Although there were persistent issues over bias and imprecision, as well as inconsistency in methods used by biologists of the United States and former USSR, their efforts were continued due to a perceived lack of alternate methods for assessing population size (Hills and Gilbert, 1994) or different approaches for management. However, by 1990, it was concluded that such surveys produced data unsuitable for accurately estimating population size or quantifying trends (Hills and Gilbert, 1994). Since then, new methods involving airborne remote censusing were developed (Burn et al., 2006; Jay et al., 2006), resulting in an attempted full population survey in 2006, the results of which are pending.

The 2006 survey effort came at significant expenditure of personnel time and money, including years of preparation, and a $1 million U.S. Congressional appropriation. As is normal with population surveys of vast areas in remote regions, there will likely remain some significant uncertainty associated with the variables and correction factors required to calculate the resultant population estimate. Cost and personnel time will also likely preclude future surveys every four years, leading to Taylor et al.'s (2007) conclusion that population declines would not be detected. Furthermore, even assuming that an accurate and precise count is obtained, population size alone provides no information on the relationship between walrus numbers and their changing environment: for example, whether population changes are a result of changes in reproductive rate, mortality, carrying capacity, or a combination of the three.

Counts of walrus on land provide some benefits for assessing specific components of the population while hauled out on the coasts of Alaska and Chukotka. However, here too, observational errors can be significant (Udevitz et al., 2005), and dynamic regional walrus distributions can thwart learning how changes in recorded abundance at specific sites relate to overall population numbers (Hills, 1992). For example, decreased numbers at a specific terrestrial haulout could reflect animal movement to another more suitable habitat, at least temporally, rather than a changing population. At Round Island, Alaska, counts are predominantly of males, limiting inferences in assessing the status of females, which more directly determine population growth rate.

Given the lack of reliable population estimates, the tissue collection program (teeth and reproductive tracts) begun by the State of Alaska during the 1960s and partially continued by USFWS since the inception of the MMPA has provided the most recent indications of possible changes in the age structure, productivity, and status of the walrus population. Multiple factors, however, including biases in hunter preferences, harvest management regimes, environmental conditions, and changes in the walrus population complicate conclusions (Garlich-Miller et al., 2006). Lack of attendant data on walrus (e.g., recruitment rates or age/gender-specific survival) or environmental health limits conclusions about the relationship between population size and the dynamic carrying capacity of the Beringian region.

Ecosystems and the Marine Mammal Protection Act

The intense focus on numerical counts of marine mammal populations comes at the expense of the primary intent of the MMPA. The Congressional findings and declaration of policy in the MMPA emphasize goals of ecosystem function over those of absolute numbers of marine mammals:

> *Marine mammals have proven themselves to be resources of great international significance, esthetic and recreational as well as economic, and it is the sense of the Congress that they should be protected and encouraged to develop to the greatest extent feasible commensurate with sound policies of resource management and that the primary objective of their management should be to <u>maintain the health and stability of the marine ecosystem</u>. Whenever consistent with this primary objective, it should be the goal <u>to obtain an optimum sustainable population keeping in mind the carrying capacity of the habitat</u>.* (Emphasis added. 16 USCS § 1361(6)).

This statement instructs managers to attend to the "health and stability" of marine ecosystems. However, "stability" is largely a misnomer, as ecosystems are always in flux and can exist in different states (Link, 2002). That is, ecosystems are systems in a balance between negative and positive feedbacks that tend to stabilize or destabilize a particular and potentially transient state. The preferred ecosystem state under the MMPA is explicitly where marine mammals are in such numbers that they represent functional parts of ecosystems. I prefer to use the term '*resilience*' as synonymous with the intent of 'health and stability' within the MMPA. Resilience in this context denotes the capacity of an ecosystem state to retain the characteristics necessary to support a population of a species like walrus, as a significant functioning element, while maintaining the capacity of the walrus population to absorb a spectrum of endogenous and exogenous perturbations. From this perspective, the MMPA encourages actions that tend to stabilize system states encompassing marine mammals as significant functional elements.

Developing ecosystem management tools is a logical interpretation of the MMPA's primary goal of maintaining ecosystem resilience. However, the fundamentals of ecosystem management were not well articulated under that moniker until the 1990s (Larkin, 1996; Christensen et al., 1996), well after the implementation of the MMPA (although Eberhardt, 1977, and much earlier Aldo Leopold (1933) and George Perkins Marsh (1874) provided renditions covering similar concepts). Programs considered or implemented under the MMPA that focus on *secondary* (population) objectives, rather than the primary ecosystem objective of the Act are considered ironic, paradoxical, or even tragic (Reynolds, 2005, Fay et al., 1989). Below I discuss why the MMPA's secondary objectives have been invoked in attempts to manage marine mammals, and why for the walrus ecosystem of Beringia this is especially problematic.

Population-Based Approaches to Marine Mammal Management

Knowledge about population status and trends in abundance are considered by many as requisite for effective management, understanding, and conservation of marine mammal populations (e.g., Garner et al., 1999; Small et al., 2003; Punt and Donovan, 2007; Taylor et al., 2007). Consequently, few management approaches for marine mammals have been advanced that do not require numerical validation of population size. This general focus on numbers rather than the ecosystem-based intent of the MMPA is a consequence of management history, implementation of goals, and path-dependent action. In its original findings, (MMPA §2(1)), Congress stated that certain marine mammals had been depleted or were in danger of extinction due to adverse human actions. Congress further declared that:

> *...such species and population stocks should not be permitted to diminish beyond the point at which they cease to be a significant functioning element in the*

ecosystem of which they are a part, and, consistent with this major objective, they should not be permitted to diminish below their optimum sustainable population. Further measures should be immediately taken to replenish any species or population stock which has already diminished below that population. In particular, efforts should be made to protect essential habitats, including the rookeries, mating grounds, and areas of similar significance for each species of marine mammal from the adverse effect of man's actions (MMPA §2 (2)).

The National Marine Fisheries Service (NMFS) and USFWS jointly administer the MMPA (NMFS overseeing seals while USFWS oversees walrus). When adopting implementing regulations, NMFS defined operational goals relating to maintaining or restoring stock size in relation to carrying capacity (Federal Register, 21 December 1976, 41 FR 55536). USFWS accepted the same "optimum sustainable population" (OSP) operational goal, and both agencies subsequently moved to develop a strategy for stock assessments required under the 1994 amendments to the MMPA. NMFS interpreted the management goals of the MMPA (perhaps due to the then unresolved scope of ecosystem management) as to ensure marine mammal species were a part of ecosystems in sufficient numbers, and not that their ecosystems were maintained or enhanced to achieve optimum numbers (such as by protecting essential habitats). Nevertheless, OSP for a species incorporates habitat, and thus, from a theoretical perspective, is inextricably linked to ecosystem goals. OSP is defined with respect to any population stock as:

the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element (16 U.S.C. §1362(9)).

A greater emphasis on the "maximum productivity" component of OSP, compared to habitat, may lead to management resembling problematic aspects of traditional resource management such as maximum sustainable yield (Bean and Rowland, 1997). Conversely, too great a focus on habitat may be incompatible with other ecosystem or socio-economic objectives. Confounding these challenges, OSP may "call for subjective value judgments that are not amenable to quantification on the basis of available data" (citing the Marine Mammal Commission; Bean and Rowland, 1997).

Irrespective of the confusion over how to effectively implement an OSP approach, NMFS accepted the dynamic nature of OSP and by regulation defined populations to be at OSP when they were between carrying capacity and the maximum net productivity level (MNPL; Gerrodette and DeMaster, 1990), recognizing that the MNPL would exist at a point below carrying capacity. USFWS subsequently endorsed the NMFS definition (USFWS, 1994):

> *Optimum sustainable population is a population size which falls within a range from the population level of a given species or stock which is the largest supportable within the ecosystem to the population level that results in maximum net productivity. Maximum net productivity is the greatest net annual increment in population numbers or biomass resulting from additions to the population due to reproduction and/or growth less losses due to natural mortality.* 50 CFR § 403.02.

Three numbers are required to ascertain population status under an OSP assessment; population size at carrying capacity, population size that would produce the maximum net productivity, and the present population size. However, these numbers have rarely been successfully collected and usually are associated with significant uncertainty (Taylor et al., 2000). Nevertheless, an administrative law judge in 1977 determined that the maximum net productivity level of Pacific walrus was at least 170,000 animals, and in 1994 USFWS correspondingly indicated that walrus populations would be regarded at or above OSP if subsequent surveys indicate that their population is 170,000 or more (USFWS 1994).

In addition to the difficulties of assessing population, assessing carrying capacity is problematic and remains a significant "loose end" in implementation of the MMPA (Goodman, 2005). For example, the correct temporal dimension of carrying capacity is unresolved, but might take a historical, current, or dynamic approach. A dynamic approach to carrying capacity might also consider anthropogenic versus natural change. For example, decreasing carrying capacity in OSP calculations when habitat is degraded by humans is regarded by some as contrary to the spirit of the MMPA (Gerrodette and DeMaster, 1990). Nevertheless, using historical carrying capacity as a standard may be unreasonable or even unachievable in some cases (Marsh et al. 2005). Clearly, under directionally changing environmental conditions, carrying capacities may be transient and not reflective of past or contemporary ecosystem conditions.

In 1994, NMFS made a significant departure from the OSP approach by adopting the potential biological removal (PBR) concept (Wade 1998). PBR is:

> *...the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population* (MMPA§3(20))

The amendment implicitly assumes that anthropogenic mortality is the main threat to marine mammal populations (Taylor et al. 2000; 2007). The PBR management concept originated in proposals submitted by the NMFS, the Marine Mammal Commission, fishing groups and environmental organizations seeking to: (1) explicitly consider uncertainty in management, (2) base management on parameters that could be estimated, and (3) provide incentives to gather better data (Taylor et al. 2000). This last objective sets in motion management path-dependence. If managers seek better data to assess stocks, more resources are shifted in the organizational budget to accommodate that goal. Thus primacy of population analysis becomes institutionalized over other goals, such as habitat assessment.

PBR, by definition, relies on OSP for context, although PBR does not implicitly resolve what an OSP should be for a particular species. Practically, PBR takes a numerically precautious approach that legally limits direct anthropogenic take of marine mammals to levels that support the minimum estimated population maintaining at least half a population unit's carrying capacity in a given environment. However, even a conservative focus on direct anthropogenic mortality negates other sources of mortality such as those that result from prey depletion, ecosystem changes, predation, habitat degradation, and disease. Thus, PBR does not in itself foster a precautionary ecosystem-based approach, deferring ecosystem-oriented factors (that were implicit to the primary goal of the MMPA and to the definition of PBR through the context of OSP) to post-depletion attention.

Although the PBR scheme regards non-anthropogenic factors as less significant than direct human-caused mortality of marine mammals (Taylor et al., 2000), many of these factors may still be related (although indirectly) to human-induced environmental change. For example, global climate changes have an anthropogenic component (ACIA, 2005), but because they occur globally, are difficult to attribute to a specific human group that the MMPA can manage. Furthermore, some marine mammal species continue to decline for reasons apparently separate from direct human-caused mortality (e.g., western stock of Steller sea lion, several harbor seal stocks, southwest stock of sea otter, and the Hawaiian monk seal).

PBR was originally intended to address incidental take in commercial fisheries, seeking a maximum annual removal limit for specific stocks (Read and Wade, 2000), which focused management solutions under the MMPA on take reduction. Thus, for species with a subsistence harvest, PBR perhaps unintentionally became a default method for assessing appropriate harvest levels. The Native harvest of Pacific walrus, although recently regarded as reasonable by USFWS (Ray and McCormick-Ray, 2004), was until recently the primary *known* source of walrus mortality. In comparison, past estimates of natural mortality were 1.5 % annually (Fay et al., 1997), which, based on a historical population estimate of approximately 250,000 walrus, represent about 3750 walrus, about half the range-wide harvests of 6,000-9,000 walrus in the mid 1980s (Fay et al., 1997). However, range-wide harvests levels were reportedly halved to 2,400 - 4,700 walrus in the 1990s (Garlich-Miller et al., 2006). In contrast, large-scale environmental changes are expected to increase natural mortality, in part from a reduced environmental carrying capacity for walrus. For example, observations of natural mortality of walrus on haulouts in northern Chukotka during the extreme ice retreat of 2007 suggest that 3,000-4,000 walruses died, composed mostly of young animals (Personal communication with Anatoly Kochnev, Chukotka TINRO). Therefore, natural mortality could now equal or exceed direct anthropogenic removals (see similar arguments for whales in Burns, 2001).

Effective use of OSP and PBR approaches to management require data of sufficient resolution, confidence, and frequency to justify effective management action rather than inaction (Taylor et al., 2007). Both OSP and PBR also require reference to a specific population unit (Taylor, 1997) requiring stock delineation in conjunction with population surveys. Referencing specific population units emphasizes that OSP and PBR are still reflective of biological, and not necessarily ecological units (Ray, 2006). Furthermore, for OSP and PBR to be biologically meaningful, they require the application of concurrent demographic parameters, which can be missed in broad population assessments.

Accurately assessing anthropogenic removals is likewise problematic. Recent annual estimates of the landed harvest of Pacific walrus by Native hunters generally relied on direct observations from USFWS harvest monitoring programs and more recently on the statutorily-required USFWS marking, tagging, and reporting program (MTRP) that registers walrus ivory (although it does not provide information for accurate assessment of age/sex composition of the harvest or for indications of annual productivity). Discrepancies between the two USFWS programs, as well as with other household subsistence surveys, confound biologists' estimates of take, as they require a correction factor to be assigned to the MTRP numbers (Garlich-Miller and Burn, 1999). In addition, some walrus are lost during harvesting. This number (termed struck-and-loss) is needed to establish the total number of walrus removed from the population by hunting, on an annual basis. Struck-and-loss rate for walrus was most recently reported in the scientific literature as 42% during the period 1952-1972 in Alaska, and 40 % in Chukotka during the 1960s (Fay et al., 1994). I expect the proportion of struck-and-lost walrus to have changed in the subsequent 35 years. It is likely to vary among communities, as well as with hunting methods and changing hunting practices. For example, deteriorating sea ice conditions and changed seasonal distributions of walrus may present communities, some of which have less experience hunting walrus, with conditions less suitable for securing wounded animals and butchering carcasses. However, a new assessment of hunting losses would require challenging surveys of each walrus-hunting community and is not currently planned.

Court rulings have pointed to lack of precision and accuracy of parameters used in marine mammal stock assessments, with the result of invalidating NMFS' permit requirements or mitigation strategies (NOAA 2004). This further reinforces the perceived need to define numeric parameters more precisely, rather than focus on other MMPA goals. Although NMFS has expressed a desire to shift from a stock assessment to ecosystem-based management approach for marine mammals (which USFWS would presumably support), they have insufficient staff to do so, and are lacking key data that would support such a shift (NOAA, 2004). Currently, NMFS is striving to achieve the basic level of data necessary to comply with mandates of the MMPA and ESA, which again focus on reducing take to support an OSP approach, while largely avoiding ecosystem-based approaches (NOAA, 2004). The 1994 USFWS Walrus Conservation Plan (USFWS, 1994) also recognized the difficulties associated with an OSP approach for walrus:

> *OSP for walruses cannot be defined in a statistically rigorous manner since carrying capacity (K) is not known and MNPL can not be calculated with precision. Estimates of four critical values - current population size, annual female harvest rates over the last 150 years, K, and where MNPL occurs relative to K currently are insufficient for precise calculation of OSP range....Regardless of funding levels, precise determination of MNPL relative to K is very unlikely in the foreseeable future....*

Despite, or perhaps because of this recognition of difficulty, USFWS ranked assessing walrus stock parameters as one of its top priorities in the coming years (USFWS 1994). Currently, there is no program in place to address *K* and MNPL within a dynamic ecosystem-based context. This will perpetuate the problem of continuing the numerical population approach without the ability to attribute causation, and consequently the ability to prescribe appropriate and perhaps proactive interventions.

Waiting for a Crisis in Walrus Management?

I emphasize that the focus on population enumeration is a consequence of an interpretation of the MMPA that differs significantly from the MMPA's primary ecosystem-based intent. I think this is a particularly unfortunate situation where existing scientific evidence indicates that degradation of stocks or their habitats are occurring, leaving managers to monitor a species or stock's decline rather than doing something about it. Conversely, there are cases where populations were healthy, and drastic management actions were based on faulty findings of depletion (Huntington, 2000). These situations often lead to a crisis of expensive and time-consuming mitigation measures that divide stakeholders, based on their differing goals and objectives.

I contend that current management practices do not generally support proactive species or ecosystem management (the primary goal of the MMPA), maintain pagophilic pinniped species at OSP (the secondary goal of the MMPA), or promote trust and collaboration with Native communities and other stakeholders (a tertiary goal of the MMPA). Consequently, Ray (2006: 1825) asks what information is required to reduce uncertainty to a point where "decision makers and the public will accept the conservation practices that are already apparent from knowledge at hand?" I do not intend to imply that there is no value in determining population size or estimating OSP or PBR <u>when feasible</u>; rather, the production of these estimates reduces resources available to managers. Fiscal and intellectual resources could alternatively be used to assess habitat, trends in the quality of that habitat, and other important population parameters such as demographic composition, reproductive potential, and health. The numeric focus has also perpetuated legal intransigence associated with lawsuits over methods and means of assessing a marine mammal population, rather than how desired outcomes can be fostered through more comprehensive attention to the more easily measured factors that impact a marine mammal population's status (Figure 2-1; Nichols and Williams, 2006 and Svancara et al., 2005 provide similar arguments elsewhere).

The legal requirement under the MMPA is to use the best available scientific information available to manage marine mammals (Goodman, 2005). The PBR scheme provided a practical way forward in addressing direct anthropogenic mortality. Nevertheless, PBR calculations for several species remain problematic and, as I demonstrate, do not address important contextual factors associated with OSP that provide the primary context for both PBR and the MMPA. In effect, PBR added direct anthropogenic mortality to the definition of OSP, requiring from an ecosystem perspective, a more data-intensive parameter. Several authors (Goodman, 2005; Hobbs and Hilborn, 2006; Brandon et al., 2007) focus attention on alternative numeric approaches such as likelihood, information theoretic, and Bayesian analyses. However, I argue that, if ecosystem management seeks to "capture the essential dynamics with minimum increase of complexity" (Garcia and Charles, 2007: 585), even the collection of a few statistically valid numbers in isolation may complicate relatively clear situations, evident on the basis of less quantitative knowledge of an ecosystem. The best available numbers (or the best available technology to collect those numbers) are not necessarily consistent with the best available science. My focus therefore is toward alternative methods for assessing the status and health of marine mammal stocks, although still based on the best scientific evidence. This requires detailed observations of walrus ecology at multiple scales. Under my proposed ecosystem-based approach, management actions are informed by known ecosystem stressors and needs (dovetailed with population estimates and other indices as known), which are incorporated into a process of proactive and adaptive ecosystem governance.

A Fresh Approach

Ecosystem-based approaches seek to balance diverse societal objectives; account for knowledge and uncertainty about biotic (inherently including human factors) and abiotic components, and interactions within ecosystems; and apply management actions at scales that are meaningful to ecological functions (Christensen et al., 1996; Garcia and Cochrane, 2005; Link, 2002; Pikitch et al., 2004; Harwood, 2007). Link (2002) describes a continuum (rather than a dichotomy) that runs from single-species approaches to full ecosystem approaches. The greater the focus on single-species management (seeking to maximize multiple but separate objectives), the fewer ecosystem factors can be incorporated (that explicitly consider trade-offs among objectives). An ecosystem approach favors proactive consideration of how to resolve and allocate trade-offs among stakeholders (Rosenberg and McLeod, 2005; Garcia and Charles, 2007). Here, this represents the desired relationship between marine mammals and people rather than the reactive and "frenetic, lawsuit-driven response to crisis" that currently exists (Reynolds, 2005: 2). From a scientific perspective, the wider purview of an ecosystem-based approach to marine-mammal management requires an interdisciplinary focus that includes among other things, a complex array of anthropocentric factors such as economics, cultural values, and social conditions across scales and cultures (Marsh et al., 2003; Hughes et al., 2005; Berkes et al., 2007; Hammill and Stenson, 2007). The best available science that guides ecosystem management will therefore come from a broad suite of expertise and would likely require reallocation of agency resources.

A promising line of interdisciplinary research with respect to managing the complexities of marine resource systems has been the concept of governance, which includes the broader social contexts that are required for effective ecosystem-based management (Folke et al., 2005; Young, 2005; Berkes et al., 2007). Ecosystem governance is a move away from a primary focus on assessment of maximum sustainable yields of an individual species over broad scales, toward a more general focus on the essential ecological processes that sustain the delivery of harvestable resources and other ecosystem services over multiple scales. Governance is a "set of regulatory processes, mechanisms and organizations through which political actors influence environmental actions and outcomes" that implicitly includes multiple actors, not just the state (Lemos and Agrawal, 2006: 298). Co-management structures, now encouraged under Section 119 of the MMPA, are such a form of governance that explicitly seeks to create a space for meaningful and equitable inclusion of Alaska Natives in resource management.

Governance approaches generally accept the need to foster experimentation and learning, frequently referred to as 'adaptive' approaches (Folke et al., 2005; Hughes et al., 2005). Managers are commonly faced with incomplete information and understanding with which to make decisions, as is the case for many marine mammals. These approaches therefore incorporate uncertainty, but depart from numerical efforts in their preemptive focus on actions that favor desired ecosystem functions, such as the maintenance of marine mammals as significant functioning elements (Pikitch et al., 2004; Marsh et al., 2005; Pitcher, 2005). Scaled decision rules can be developed among stakeholders based on risk, that are responsive to both qualitative and quantitative information as it becomes available (Astles et al., 2006; Punt and Donovan, 2007). However, adaptive governance may be challenged by two "catch-22" conditions: first, changes in governance are most likely under conditions of controversy such as a depletion (Lee, 1993); and second, a legal finding of depletion is likely to lead to greater government oversight, which can inhibit local conservation-oriented collective action (Holt, 2005), Nevertheless, adaptive governance provides significant opportunities to develop mutually beneficial working relationships across cultures that emphasize learning and communication toward achieving collective goals, in this case, maintenance of walrus as a significant functioning element of the Beringian ecosystem.

Potential Elements of Ecosystem-Based Management for Pacific Walrus

My primary argument is that, although there is no currently accepted population estimate for the Pacific walrus, and because we are unlikely to detect a decline using current methods, we nevertheless know enough to proactively implement adaptive governance using scaled decision rules. A basic premise of adaptive walrus governance within the Beringian region under the MMPA would be to minimize the probability of human-induced system state transitions to less desirable states by increasing, if possible, the resilience of desired ones. From biological, ecological, social, political, economic, and cultural perspectives, transition of walrus from a legalistically defined non-depleted to depleted status may be such an undesired transition. Establishing policy targets to minimize the probability of walrus becoming legalistically and biologically depleted encourages the development of adaptive co-management institutions that can respond to changes prior to crisis.

Ecosystem-based governance regimes that seek both the health of walrus populations and their dependent subsistence-based communities will likely have to consider factors similar to ecosystem-based fisheries management (Pikitch et al., 2004). These factors include: (1) avoidance of habitat degradation; (2) minimization of risk of irreversible anthropogenic change to natural assemblages of species and ecosystem processes; (3) acquisition and perpetuation of long-term socioeconomic benefits without compromising ecosystems; (4) adoption of robust and precautionary management measures based on the best available information that favor the ecosystem; and (5) generation of knowledge about ecosystem processes sufficient to understand the likely consequences of human actions. I develop these factors below, deliberately focusing on broad themes, particularly as they relate to habitat, walrus demographics, and scale, rather than specific prescriptive measures which would need to be established among various stakeholders. I differentiate the logic of a precautionary ecosystem-based management approach from one that demands unattainable data. Data as yet unattained, may provide opportunities to assess and improve management but do not, in my view, trump precautionary implementation of interventions based on existing knowledge.

Avoid habitat degradation

Habitat degradation and reduction in carrying capacity for walrus may result from actions at local (e.g., coastal infrastructure development), regional (e.g., fishing impacts to benthos), and global levels (e.g., climate change impacts to sea ice). For walrus, which are highly mobile and depend on different seasonally available habitats, protection of those habitats is challenged by the need to incorporate species needs over a range of temporal and spatial scales. These factors affect ecological analyses, management foci, and ultimately the potential range of actions that are generally considered for management of a wildlife species.

There is currently little comprehensive understanding about the spatial and temporal patterns of walrus habitat use, either of feeding areas or of haulouts throughout their broader range. Walrus, predominantly males, are protected at the Round Island walrus sanctuary in Bristol Bay and are annually counted at that site. Yet habitat protection or assessment and use of walrus haulouts elsewhere in the State of Alaska and Chukotka, where both males and females haul out in large numbers, is relatively poor. Long-term management of haulouts in Chukotka has generally provided greater protections than in Alaska. The low number of relatively large haulouts on the Alaskan coast may be a consequence of not protecting walrus while they are at haulouts other than those in Bristol Bay. Proposals made during the early 1900s for protection of walrus habitat on the northwest Alaska coastline never came to fruition (Bernard, 1923). Female walrus were apparently forced to haul out in the thousands along this northwest Alaskan coast during 2007, due to a complete absence of sea ice over the Chukchi sea shelf.

Habitat is an important consideration due to the rapid changes in economic and social conditions throughout the Arctic and sub-Arctic regions. In addition to ongoing subsistence hunting activities, companies involved in transportation, commercial fishing, and hydrocarbon exploration/extraction are increasingly interested in the northern Bering and Chukchi seas. If my ecological scenario for female walrus and their calves manifests, there are currently few proactive protections or contingencies for walrus on parts of Alaska's coast that in future may also be of development interest.

Minimize the risk of irreversible change within ecosystems

Current analyses of the impacts of global climate change on the sea ice environment of the Beringian region suggest that changes within the system will be long-lived, due to a general warming of the ocean and positive feedbacks due to reduced albedo (ACIA, 2005). At the least, continued summer sea ice recession past the continental shelf, into the Arctic Ocean, is likely to force a greater numbers of females to forage and tend to their calves from land. Maintaining the Pacific walrus as a part of a healthy ecosystem, per the primary goal of the MMPA, is likely to require proactive responses to these changes if crisis management is to be avoided. Although the walrus ecosystem is changing profoundly, I still expect walrus can be supported as a functioning part of that ecosystem, including the people that rely on them, but recognize that carrying capacity for walrus will be reduced under predicted future scenarios.

Global production and dissemination of environmental contaminants also remain a persistent issue with respect to the arctic environment due to their bioaccumulation in arctic biota. Little is known about current contaminant levels in walrus or of trends over time. Nevertheless, interactions between climate change and contaminants, such as through increased ocean temperatures (increasing methylation of mercury), continued use of fire retardants, release of contaminants stored in arctic ice, and erosion of communities and other infrastructure into the ocean may all increase contaminant inputs and concentrations (Metcalf and Robards, 2008). Monitoring and mitigation of increased levels of persistent contaminants may be necessary to prevent long-term changes in the health and function of marine environments and subsistence systems of the region.

Obtain and maintain long-term socioeconomic benefits without compromising the ecosystem

Whereas I focused on habitat in the previous interventions, I now focus on socioeconomic components of subsistence, both from a local and national perspective. Since at least the mid-nineteenth century, walrus have been recognized as a resource susceptible to depletion from human harvests, although harvest restrictions throughout their range (crossing the political border that separates Alaska from Chukotka in Russia) can be problematic. As such, they are a common-pool resource, subject to risks of overexploitation without collective rules to guide their harvests (Fay et al., 1989). In addition, the capacity of Native communities to harvest marine mammals such as walrus has greatly increased over time due to increases in population, greater numbers of hunting boats and crews, and more efficient technology used in the hunt. Modern day hunters travel faster and range much farther than in the past. However, such evolutions in hunting capacity do not necessarily equate to increased Native harvests because cultural taboos and traditional management philosophies may not allow over-harvesting (McCay and Acheson, 1987; Berkes et al., 1989). Nevertheless, the consequence of abandoning such traditions remains troublesome to many (Young et al., 1994; Schumann and Macinko, 2007).

Pacific walrus are not legally depleted so there are no harvest limits on subsistence hunts in Alaska. Since 1972, regulations only mandate walrus should be harvested in a "non-wasteful" manner, and that products from walrus can only be used for specific purposes (Robards and Joly, 2008). Little flexibility exists under the MMPA for Native communities to explore better ways of utilizing walrus to fit contemporary circumstances; even where efforts might reduce overall harvests (Robards and Joly, 2008). In contrast, under earlier management regimes in Alaska (Department of Fish and Game during the 1960s and part of the 1970s) and now in Canada, reduced harvest limits benefiting walrus populations have been mitigated using alternative methods to maximize the value of harvested animals, thus providing opportunities to balance subsistence, economic, and conservation needs (Dowsley, 2008). However, subsistence cannot exclusively be distilled to harvest. Walrus have long provided a means to support cultural continuity, and like wildlife resources for other Native groups, can inspire an obligation or understanding of the need for reciprocity with those creatures that have helped a human community to survive. Such reciprocity however, is not exclusively limited to symbolic rituals but includes material practices that assist the survival of wildlife species (Watson and Huntington, 2008). In the modern world, the governance challenge is to develop institutions that encourage these types of relationships.

Managing walrus to the exclusion of managing the continued human-walrus relationship perpetuates divisive Native-state relations, while threatening the ecological and cultural systems that co-management aims to conserve (Stevenson, 2006). Co-managing the continued human-walrus relationship is a means to support subsistence activities, enhance the walrus population and protect its habitat, and at the same time attempt to meet subsistence goals with the lowest possible impact on the walrus population. Efforts might increase the value of a smaller harvest, conserve the reproductive potential of the walrus population through reduced harvest of females, and reduce struck-and-loss (Burns, 1965; Robards and Joly, 2008). By doing so, co-management moves from an approach that regards subsistence harvests as exempt from the MMPA, to an approach whereby the MMPA supports subsistence activities in a manner that benefits both the harvesters and the resource.

The relationship between constraints on resource utilization by remote communities and resulting social and ecological repercussions are widely described elsewhere, although outcomes are often difficult to predict (Acheson, 2006). Management that avoids addressing wider scale impacts to the walrus population, outside of the realm of a subsistence community, may be seen as inequitable (e.g., harvests in the Chukotka region of Russia, impacts of climate change on sea ice, industrial disturbance and contaminants). Harvest restrictions that are not regarded as fair and equitable at the local level, particularly in remote regions, where other economic options are limited, are neither easily, nor cheaply, enforced, and thus unlikely to provide benefits to walrus, communities that depend on them, or managers who desire knowledge of community harvest data and biological samples from harvested animals.

Use robust and precautionary management measures that favor the ecosystem

Ecosystem governance involves multiple and interacting processes at multiple scales. As such, the ability of scientists to conclusively establish causal relationships between management actions and population level processes may be limited. Consequently, Pikitch et al., (2004) recommend the incorporation of natural history parameters when developing precautionary management policies. Changes in the natural history of walrus, such as distribution, productivity, health, and behavior, may be subtle and difficult to detect. However, evidence supports a meaningful role of hunter observations to provide early and nuanced assessments of marine mammal status and behavior (e.g., see Huntington, 2000; Garcia and Charles, 2007; Moore, 2005; O'Hara and O'Shea, 2005; Berkes et al., 2007). These immediate and first-hand observations can be dovetailed with data obtained by more specific scientific techniques to provide a much greater, and mutually coherent, understanding of a population's status and trend that, in turn, informs more robust and proactive management (Metcalf and Robards, 2008).

Generate knowledge of ecosystem processes

Funding constraints play a key role in limiting the bounds of our biological knowledge about walrus. Considering that Taylor et al. (2007) do not expect that a depletion or increase can be detected on the basis of current survey techniques for pinnipeds counted on ice, and that both OSP and PBR require multiple counts, repeated population surveys can only be part of a continued and expensive endeavor that provides little understanding of ecosystem processes. In contrast, a suite of ecological indicators may be used as a tool to describe the interaction between animals and their habitat, while still providing a basis for management decisions to attain specific predefined goals (Eberhardt, 1977; Lentfer, 1988; Fay et al., 1990; Dale and Beyeler, 2001; Morellet et al., 2007).

A suite of indicators sensitive to changes in key variables (not just a questionable population estimate) for adaptive governance of walrus could help assess responses of walrus and their habitat to changes in population abundance and harvest pressure (including demographic biases), as well as how walrus are affected by changes in the range and quality of their prey or habitat. Although demographic indices alone have been used to address walrus population status elsewhere (Chivers, 1999), I recommend augmenting these with a full suite of indicators that are more fully representative of the structure, function, and composition of the Pacific walrus ecosystem (Fay et al., 1990). From a biological perspective, population demographics, condition, reproductive status, distribution, range, and behavior (e.g., foraging times) are all potential indices. From an ecological perspective, prey composition and abundance, walrus population health and distribution, as well as sea ice conditions may all be practical indices. Methods exist to accomplish biological goals using sophisticated tags attached to free-ranging animals that are deployed without having to capture walrus (Jay et al., 2006). Physiological and histological samples, as well as dietary assessments can also be obtained from subsistence harvested animals throughout their hunted range, where effective management relationships exist with Alaska Native communities (see Wikelski and Cooke, 2006 for a review of physiological applications to species conservation).

I strongly emphasize the need to not only collect additional indicators, but to frame population monitoring within models that allow for hypotheses to be tested. For example, to adaptively learn how management interventions achieve desired goals, actions should be tied to achievable research objectives. Management interventions prior to population depletion may be fundamentally different from those required within a population recovery plan, necessitating full consideration of what goals are desired (Nichols and Williams, 2006). From a management perspective, I can also learn from experience with other species. The costs and time spent on responding to depletion listings is testimony to the benefits of preemptive precautionary management.

The measurement of indicators to assess the effectiveness of management interventions is clearly an important issue, particularly for ecosystem-based approaches which may require a greater array of indicators than a population enumeration-based approach. Although an analysis of probable costs is beyond the scope of this manuscript, I argue that preventing populations of marine mammals from becoming depleted (legalistically and biologically) due to human activities based on preemptive management actions is fiscally beneficial (among other ecological and moral benefits). Ecosystem-based approaches offer greater opportunities for informed interventions toward this goal. Furthermore, an ecosystem approach offers opportunities for greater integration of studies on species groups (e.g., ice seals and walrus), perhaps providing economies of scale in addressing specific common issues.

Conclusion

I have argued that the MMPA's primary mandate is ecosystem-based, thus having the intent to prompt the assessment of ecosystem indices. Instead, it has been largely interpreted in a manner that is predicated on the assumption that an effective management strategy will naturally flow from repetitive population counts that have been difficult and costly to accomplish. However, when managers avoid incorporating ecosystem-based approaches to management because of the complexity and uncertainty associated with ecosystems, they misrepresent an approach that is premised on precaution (Murawski, 2007). By making rigorous population estimates a primary goal, biologists and managers change the focus of discussions toward statistical methods and numbers, while neglecting the important and necessary discussions of the values associated with different ecosystem properties and functions at different scales.

The MMPA calls for management that uses the best available scientific evidence toward maintaining the role of marine mammals in healthy ecosystems, maintaining an optimum sustainable population of particular species, and for respecting the rights of Native hunters. However, it is incorrect to assume that the best scientific evidence available today is the same as envisioned when the MMPA was first drafted. Evidence today crosses a range of disciplines, cultures, and scales that point toward different approaches to managing species. Like proponents of ecosystem approaches in fisheries, I propose a move away from the exclusive reliance on just one or two numerical parameters – such as population size (akin to spawning-stock biomass), and PBR (akin to fishing mortality rate) – toward a suite of indicators that can be combined to provide an assessment of a stock's resilience that can better inform an understanding and management of the multi-scale linkages of social-ecological systems (Dale and Beyeler, 2001; Trenkel et al., 2007). For fisheries, a suite of ecological indicators are often used in an effort to achieve more scientific and inclusive management. By comparison, marine mammal management has often focused on population estimates of uncertain accuracy and tried to relate them to the unknown values of *K* and subsequently to MNPL and OSP. In this sense I agree that the goal of natural resource management requires "not detailed knowledge of the parts of the system but improved understanding of the dynamics of the whole system" (Folke et al., 2005: 445).

The most recent population survey of Pacific walruses, although laudable for its technological innovation and ingenuity in addressing a complex and challenging problem, has little ecological relevance to current management challenges. I do not negate the utility of population estimates (numbers) to wildlife managers. However, in environments where numbers are not practically attainable (for either fiscal or practical reasons), I think that use of *best available but unreliable* numbers in lieu of other inputs that would urge precautionary management actions is unlikely to foster the MMPA's goals. Even with an accurate estimate of the walrus population, and if harvest size and struck-and-loss numbers could be fully and accurately determined, the challenge of managing walrus as a functioning element of the rapidly changing Beringian ecosystem would remain unresolved. Resolution requires improving knowledge about the dynamic biological (e.g., demographics, age-specific survival, reproductive rates, age at first reproduction), ecological (e.g., carrying capacity, density dependence, prey quality and availability, habitat availability), anthropogenic mortality (e.g., demographic bias in harvest, relation of actual to estimated harvests, incidental take), and other factors shaping the Pacific walrus ecosystem (e.g., increased development, contaminants). These factors should also be considered in a bilateral framework (U.S. and Russia) as part of a combined management approach for Pacific walrus throughout their range.

To monitor and respond to changes in the walrus ecosystem, I suggest incorporating scientific criteria that depend less on the necessity of enumerating population size and more on a suite of environmental and biological indicators. By doing so, precautionary actions can be made based on the known ecological needs of all pagophilic pinnipeds. Reallocating resources toward an ecological and biological indicators approach may better align timely management needs with the best available science in a manner that encourages more useful bilateral and national co-management relationships. Proactively assessing and managing walrus and their interaction with humans provides opportunities for governance as originally envisioned in the MMPA. Such a framework for adaptive governance also provides opportunities to bring together stakeholders with diverse interests and needs, over multiple scales (both spatial and temporal), around the common goal of ensuring a continued and pluralistic relationship that benefits walrus and the people that rely upon them.

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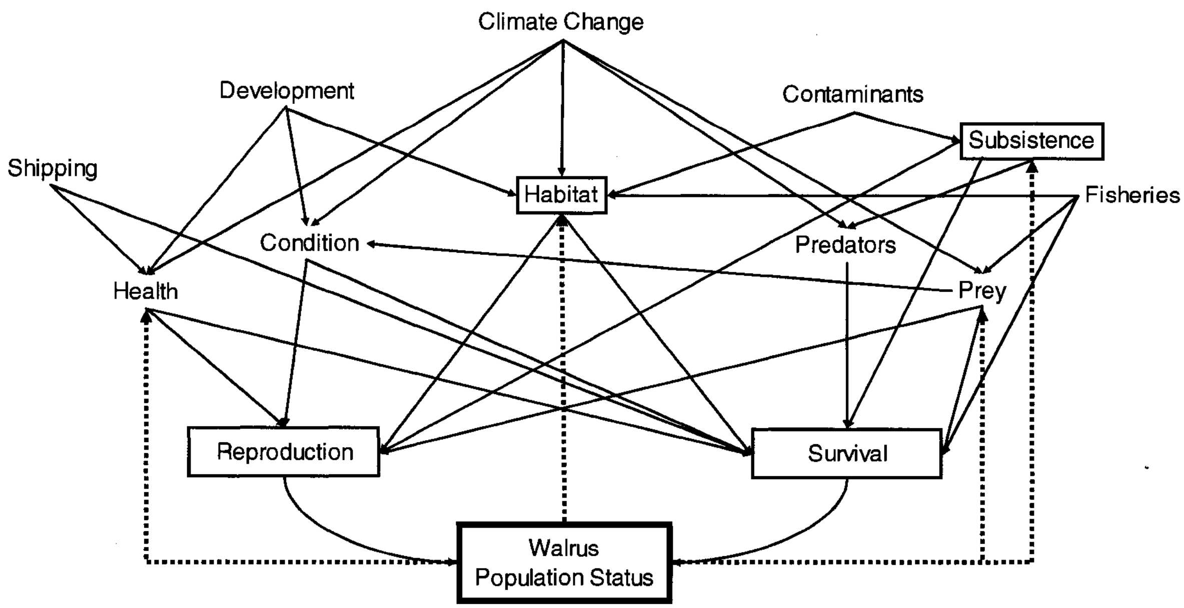

Figure 2-1. Conceptual Pacific walrus social-ecological system, locating walrus population status within the context of a suite of biological, ecological, and anthropogenic factors. Boxed terms represent key concepts within the text. Dotted arrows represent feedbacks from the walrus population to the social-ecological system as a whole. Graphic adapted from an original provided by Dr. T. Ragen, U.S. Marine Mammal Commission.

CHAPTER 3

Co-Management without Collaboration: Avoiding Spatial and Temporal "Fit" for Pagophilic Pinniped Subsistence in Alaska[1]

[1]Robards, M.D., A.L. Lovecraft, and A. Watson. Co-Management without Collaboration: Avoiding Spatial and Temporal "Fit" for Pagophilic Pinniped Subsistence in Alaska

Co-Management without Collaboration: Avoiding Spatial and Temporal "Fit" for Pagophilic Pinniped Subsistence in Alaska

Abstract

Governance arrangements such as co-management are regarded by many as promising areas for effective natural resource management between governments and indigenous resource users. However, understanding or evaluating actual outcomes of co-management requires not only a review of a statute's resource-oriented goals, but also a critical consideration of the specific goals of each co-management partner. Sustaining natural resources requires a reduction in mismatches between the scale of ecological processes regulating resources and the socio-political processes governing resource use, thus improving what is termed "fit." I argue that the fit of social and ecological processes will not be achieved when co-management partners focus on underlying political goals and values, as opposed to the statutory natural resource-oriented goals. I examine this claim by assessing spatial, temporal, and institutional fit within the political context of pagophilic pinniped subsistence co-management under the Marine Mammal Protection Act (MMPA). I find that co-management is framed by frequently incompatible and incommensurable values supported by specific choices of scale. These values reflect attitudes about ecosystems, the utilization of marine mammals, or Native rights within those ecosystems, but not of ecosystem-oriented goals mandated by the MMPA. Formalized co-management under the MMPA starting in 1994 did not support new pluralistic interpretations of the statute, or improve fit between spatial and temporal boundaries of law, management, and Alaska Native subsistence priorities. These factors compromise the ability of co-management to address the uncertainty of pagophilic pinniped population status in a manner benefiting either resource conservation or the need for Native Alaskan culture to adapt to contemporary conditions.

Introduction

The mammals of Neptune's kingdom have had a curious history of interaction with human officialdom. They have been ignored, dealt mischief, bombed, clubbed, studied, embraced, and most recently, drowned in verbiage. And, in Alaska, the story spins on.

Fay (1979)

Co-management is a form of decentralized governance, characterized by a pluralistic approach to sharing rights and responsibilities between governing entities and resource users (Kellert et al., 2000; Pinkerton, 2003; Plummer and FitzGibbon, 2004). The recent enthusiasm for co-management among policy makers has responded to calls for greater equity and efficiency in decision making, legitimization of management actions, and increased local capacity to attain specific goals (Plummer and FitzGibbon, 2004). Normative principles of the co-management process have been drawn from the resilience and commons literatures, including participation, accountability, leadership, knowledge, pluralism, learning, and trust (Armitage, 2008). However, the proliferation of co-management as a policy tool to foster sustainable resource use and social-ecological resilience has happened with, at best, equivocal evidence of what constitutes a successful co-management outcome (Plummer and FitzGibbon, 2004; Plummer and Armitage, 2007). It is the need for a coherent understanding of what constitutes success or failure in co-management, and particularly how different uses of language constrain or foster specific outcomes, that this manuscript addresses.

Co-management is a pragmatic arena of social deliberation and problem solving that attempts to fill the "institutional void" (Hajer, 2003) between governments and those it seeks to govern. Co-management is considered by social scientists as a 'deliberative space,' in which partners deliberate through the use of discourse about what defines the scope of management. Processes of discourse, such as "who speaks, how knowledge is constituted, what can be said, and who decides" enable some actions, including the possibility of new actions, while blocking or constraining others (Fischer, 2006: 19). Deliberative spaces of co-management are rarely neutral; different and sometimes irreconcilable goals may exist, often reflecting pre-existing power structures, tensions, and objectives (Morrow and Hensel, 1992; Nadasdy, 2003; Natcher et al., 2005; Howitt and Suchet-Pearson, 2006; Søreng 2006; Stevenson, 2006). Perception and definition of environmental problems (such as the need for conservation) under such circumstances depend on implicit assumptions of each culture's values and needs (Fischer, 2006; Adams et al., 2003). Consequently, success of co-management may be less about a stated goal *per se*, and more about the rights and power to interpret policy in a specific manner, at a particular place and time (Ludwig et al., 2001; Adams et al., 2003; Søreng 2006; Stevenson, 2006; Ostrom, 2007).

Co-managers of natural resources frequently state a shared normative goal of supporting both resource conservation and rational use. In this sense, deliberative spaces shared by co-management partners are expected to produce contextual conditions supportive of this goal. Such a contextual condition is "fit", where the "effectiveness and robustness of social institutions are functions of the fit between the institutions themselves and the biophysical and social domains in which they operate" (Young and Underdal, 1997). Fit is now well established as an important component of sustainable natural resource governance (Ostrom, 1990; Lee, 1993; Young, 2002; Cash et al., 2006; Cumming et al., 2006; Folke et al., 2007). In systems experiencing significant social and ecological transformation, such as the Arctic (ACIA, 2005; AHDR, 2004), the changing context of co-management may be particularly problematic because maintaining fit under rapid change necessitates the capacity for institutional adaptation through learning (Lee, 1993; Armitage, 2008).

Using co-management to foster an adaptive fit between ecosystem processes and the institutions that govern resource users is a logical approach to accomplishing conservation goals. Local users of resources are frequently the most closely acquainted with changing social and ecological processes, and their participation is now widely acknowledged as vital to adaptive types of management (Armitage, 2008). However, significant difficulties constrain the design and management of participatory processes that focus on top-down rural-development interventions (Fischer, 2006; Li, 2007). Seeking to better understand the increased role of citizen participation in governance, Fischer (2006) calls for more attention to cultural politics within deliberative spaces. Participation and empowerment do not just happen, there has to be what Holcombe (1995: 21) describes as "a strategy and a set of actions to allow them to develop." I argue that these strategies and actions include the need for co-management to produce a political context conducive to desired outcomes at the level at which subsistence takes place, although I caution that desired outcomes of co-management are themselves contingent upon cultural worldviews and needs expressed through discourse (Morrow and Hensel, 1992; Nursey-Bray, 2006).

Governments use political power to construct knowledge for implementing and enforcing policies that divide (e.g., as indigenous) and categorize (e.g., as illegal), but also structure power to internalize particular subjectivities, the way people perceive themselves and their environment (Lukes, 1974; Bourdieu, 1977; Foucault, 1980; Bryant, 1998; Rose, 1999; Agrawal, 2005). Nevertheless, numerous ethnographic studies also suggest that the same institutions that legitimate political or economic domination of one class, gender, or culture, simultaneously and contradictorily create space for opposing discourses and actions (Silvern, 1999; Li, 2002, 2005; Agrawal, 2005). Similarly, I want to avoid simplistic dualisms pitting government against individuals, and structure versus agency. The needs and desires that co-management partners bring into a deliberative space may also transcend natural resource-oriented objectives such as improving fit, to broader issues such as affirming identity, and establishing social, political, and legal status (Korsmo, 1990; Davis and Jentoft, 2001; Li, 2002; Kuper, 2003).

Fay's (1979) assertion that marine mammals are drowned in verbiage accompanied the transition of marine mammal management in Alaska from State to Federal oversight in the 1970s. During the 1960s the State of Alaska administered a marine mammal program focused on "fit" with extensive local involvement based on strong commitments by a few biologists (learning local languages and living in communities over long periods); knowledge production encompassing the ecological, social, and economic components of subsistence; and compliance with management restraints that fostered conservation. The promulgation of the MMPA largely extinguished this State of Alaska program, in part as a result of contested rights between tribes, the State of Alaska, and the Federal government. Increasingly formalized spaces of co-management arguably focus attention on rights of access, withdrawal, and management associated with subsistence, rather than fitting management to known threats to marine mammals themselves. The deliberative space of co-management has now become consistently contentious because parties produce and deploy different discourses to describe the same phenomena in the world, and these discourses are based on different worldviews and rights-based objectives (e.g., Huntington, 1989; Nursey-Bray, 2006; Robards and Joly, 2008).

I propose that co-management partner-specific goals that detract from improving institutional fit may be illuminated through observing how boundaries of space and time are framed in policy. Elsewhere, Mansfield and Haas (2006) and Campbell (2007) focused on the politics of spatial scale. Here, I develop a greater focus on the framing of temporal and economic scales, recognizing the potential for contested views of desired ecosystem and social states in complex adaptive systems. I use the Institutional Analysis and Development framework (Ostrom,

2007) to analyze how discourses of space and time at the collective choice level of co-management often oppose achieving fit (Figure 3-1). In doing so, I suggest a need to divide investigations of the political outcomes of co-management into two levels: first, the collective choice level framing of problems that I address here; and second, the more commonly assessed efficacy or outcomes of operational-level rules, which add a complex suite of community-specific challenges (Armitage, 2005; Plummer and FitzGibbon, 2006).

I use a case study of pagophilic (ice-loving) pinniped co-management in Alaska to bridge the literatures of political science and political ecology in a manner that addresses practical concerns of assessing the effectiveness of co-management. Alaska's pagophilic pinnipeds include walrus *Odobenus rosmarus divergens*, and four species of ice seal: bearded *Erignathus barbatus*, ribbon *Phoca fasciata*, ringed *P. hispida*, and spotted *P. largha*. These species are difficult to census, so population status is unknown, and not legally 'depleted' or 'strategic' under the U.S. Endangered Species Act (ESA) or MMPA. However, despite lacking management crisis, pagophilic pinnipeds are expected to decline in abundance if summer sea-ice extent deteriorates as predicted (Kelly, 2001; Robards et al., *submitted*), or subsistence harvests exceed the capacity a species can support. I argue that changes in sea-ice and hunting represent "real" components of pagophilic pinniped ecology, and consequently to Alaska Natives reliant on them for subsistence (Metcalf and Robards, 2008). However, I illuminate different discourses of scale in *ecology* as representations of the biophysical world (as did Mansfield and Haas, 2006 and Campbell, 2007), and discourses about *Native* and *what is a Native lifestyle* as different representations of the socio-political world (as did Morrow and Hensel, 1992). Legal discourses support and are shaped by specific rights and values. I argue that discourses that focus on rights and values rather than "fit" preclude attaining the conservation objectives of the MMPA. I first review theoretical aspects of scale, resources, and property rights.

Scale

Scale is perceived and valued differently among different people at different times, including between natural and social scientists (Cash et al., 2006; Manson, 2008). For natural resource management, scales include spatial (the area considered), temporal (rates, durations, and frequencies), functional scale of management (jurisdictions, institutions, networks, and knowledge), and the scale of economic activities (Elazar, 1999; Cash et al., 2006; Cumming et al., 2006; Dowsley, 2008). Because the MMPA calls for use of the "best available science," which itself is scale-dependent (Francis et al., 2005), I anticipate that effective co-management of "fit" necessitates use of both natural and social science methodologies. For example, the transition from socially-constructed understandings of ecosystem stability to ones that are multi-scalar, dynamic and complex has in particular challenged policy to adapt in a manner that allows it to respond effectively to "surprise" events (Holling, 1986). Likewise, as either social or ecological processes change at different scales, the political context of co-management may no longer represent objective realities, or an allocation of rights conducive to better matching these processes.

Types of Resource and Property Rights

Pagophilic pinnipeds are common-pool resources: once an animal is harvested, fewer animals remain; and exclusion of beneficiaries through physical or institutional means is either impossible or especially costly (Ostrom et al., 1999). Ownership of common-pool resources through a variety of institutional methods controlling access and use of resources is regarded as important for sustaining these resources, as well as effectively implementing co-management (Yandle, 2003). Property rights are bundles of entitlements that define access privileges and limitations for use of natural resources (Bromley, 1991). Property represents a structure of rights and duties that imply legal entitlements enforced by a system of authority. Under open-access, rational choice theory demonstrates that resource users find few incentives to invest in sustaining resources. Each harvester, or group of harvesters, receives all benefits from their own exploitation, but costs of that exploitation are shared among all stakeholders. Under open-access, fewer incentives exist for unilateral harvest restrictions, as those that show restraint incur all the costs of that restraint, while other users share all the benefits.

Allocation of Rights to Common-Pool Resources

Allocating rights to distinct groups of people is contentious because of power issues associated with who allocates those rights, and of the repercussions of including (increasing competition) or excluding people from resources (removing livelihoods). As a consequence, allocation is central to many natural resource conflicts (Ostrom et al., 1999; Sepez, 2002; Søreng 2006; Armitage, 2008). For indigenous groups, the threat of externally imposed restrictions may require them to think "about who they are and what they do in terms of such dry and lifeless legalisms such as 'rights' and 'privileges'" (Davis and Jentoft, 2001). The rise of Alaska Native Organizations (ANOs) protecting the rights of Alaska Natives to hunt marine mammals is such an adaptation to emergent political threats to continuation of Native subsistence. ANOs were central to constitutional level decisions that supported the transition from State of Alaska to federal management of marine mammals in Alaska, and thus the rule-sets under which Alaska Natives live.

Constitutional level rules set conditions for the collective choice level of co-management. Collective choice rules, in turn, aim to shape the formation of operational rules of day-to-day activities of hunters. Collective choice rules differ from operational, by allowing holders to participate in defining future rights. Governments may also not fully control a resource that is not permanently within territorial waters. In these cases, a species may remain ostensibly open-access unless alienation rights are ceded through formal or informal international treaties and agreements (Young, 2005; Meek et al., *in press*).

Temporality of Rights and Resources

Changes in Arctic ecosystems, social norms, values, and world views, alter both current and desired relationships between people and marine mammals, and thus, the desired allocation of property rights that support specific goals (Yandle, 2007; Armitage, 2008). For example, a transition to mixed-economies by Native communities alters the balance between sustenance and economic components of subsistence. Flux and transformation of ecosystems and human communities in the nearly 40 years since promulgation of the MMPA challenges the relevance of policies in matching contemporary scales of biophysical and sociopolitical processes. Even with new understanding about a changing environment, resolving mismatches between the spatial and temporal scales of ecological processes and the institutions of governance is a difficult collective action problem (Lessig, 1995). The significant time and fiscal costs associated with such a mismatch are clearly demonstrated in the management of Cook Inlet belugas in Alaska (Weber and Laist, 2007).

Allocation of Rights to Marine Mammals under the Marine Mammal Protection Act

In contrast to the broad support for large-scale marine mammal hunting in the nineteenth and early twentieth century, contemporary Western values are more discordant with marine mammal harvests, either commercially (Young et al., 1994; Stoett, 2005) or for subsistence (Reeves, 2002). Western values have supported increased centralization of control over the rights to marine mammals. This has been accomplished through institutions such as the International Whaling Commission (IWC) and the U.S. Congress promulgation of the MMPA in 1972, which consolidated rights to the take of marine mammals from a suite of coastal states to two agencies – U.S. Fish and Wildlife Service (USFWS) and National Marine Fishery Service (NMFS).

The express purpose of the MMPA is to conserve marine mammals as significant functional elements of marine ecosystems. The Federal government also recognized the intrinsic role that marine mammals have played, and continue to play, in subsistence by Alaska Natives, with an exemption to the general moratorium on take of marine mammals under the MMPA (16 U.S.C. 1371 § 101 (b)).

> *...the provisions of this Act shall not apply with respect to the taking of any marine mammal by any Indian, Aleut, or Eskimo who resides in Alaska and who dwells on the coast of the North Pacific Ocean or the Arctic Ocean if such taking –*
> *(1) is for subsistence purposes; or*
> *(2) is done for the purposes of creating and selling authentic native articles of handicrafts and clothing: <u>Provided</u>, That only authentic native articles of handicrafts and clothing may be sold in interstate commerce: <u>And provided further</u>, That any edible portion of the marine mammals may be sold in native villages and towns in Alaska or for native consumption. For the purposes of this subsection, the term "authentic native articles of handicrafts and clothing" means items composed wholly or in some significant respect of natural materials, and which are produced, decorated, or fashioned in the exercise of traditional native handicrafts without the use of pantographs, multiple carvers, or other mass copying devices. Traditional native handicrafts include, but are not limited to weaving, carving, stitching, sewing, lacing, beading, drawing, and painting; and*
> *(3) in each case, is not accomplished in a wasteful manner.*

In 1994, the MMPA was amended with Section 119 authorizing formal cooperative agreements between federal agencies and ANOs. These agreements are intended to help conserve marine mammals and provide co-management of subsistence. In 1994, USFWS defined co-management as "two or more entities, each having *legally* established management responsibility, working together to actively protect, conserve, enhance, or restore fish and wildlife resources" (USFWS, 1994: 8; emphasis added). However, MMPA Section 119 does not establish or recognize the legal responsibly of ANOs toward:

> *(1) authorizing any expansion or change in the respective jurisdiction of Federal, State, or tribal governments over fish and wildlife resources; or*
> *(2) altering in any respect the existing political or legal status of Alaska Natives, or the governmental or jurisdictional status of Alaska Native communities or Alaska Native entities.*

Although the MMPA requires "best available science" to help support ecosystems in which marine mammals remain significant functioning elements, the role of science in policy is neither straight forward or rational (Houck, 2003; Howitt and Suchet-Pearson, 2006). The MMPA is a constitutional level rule that awaits clear definitions for a suite of terms. For vague statutes such as the MMPA, federal agencies have greater discretionary authority in their interpretation (Spicer and Terry, 1996). Under discretionary situations, agencies have a degree of *de-facto* constitutional rights, whereby they create meaning in policy, negating the view that co-management is embedded at the collective choice level. The "judicial deference" doctrine provides an internal balance on agency interpretation, but may still represent values more aligned with agency or Congressional culture, than Yup'ik, Siberian Yupik, or Iñupiaq Alaska Native communities who subsist on pagophilic pinnipeds (Robards and Joly, 2008). Therefore, although Alaska Natives can harvest non-depleted marine mammals, co-management is framed in a political context of preexisting rules set at the constitutional level, which negates clear operational level feedback between hunters and the collective choice mechanism provided by co-management in a manner supportive of learning and adaptation of policy. ANOs do not hold the collective choice rights supporting reinterpretation of the constitutional rules. Here, I argue that constitutional level rules set in 1972 for Native subsistence of marine mammals "marginalize and trivialize indigenous perspectives on the relationship between people and place" through ontological privilege of non-indigenous perspectives, that are manifested in policy through discourses of scale (Howitt and Suchet-Pearson, 2006: 323).

Legal Discourses of Scale

In this section I examine the differences in values between managers and hunters as expressed in discourses concerning the MMPA Native exemption. The Native exemption and the section 119 amendment loosely mirror the collective action needs of managing marine mammals;

first allocating harvest rights to a specific group, and second supporting management. I expect discrepancies in collective choice interpretations of constitutional level rules, from those that promote fit represent underlying values and the "messy, contradictory, multilayered, and conjunctural effects" of what governance actually does (Li, 2005: 384). In other words, as different actors work to create a better fit of pinniped populations, conservation, and indigenous hunting needs, the tensions and conflicts which arise are indicative of differences in values held by managers, hunters, or wider society. I assess this proposition through analysis of the following terms: *Alaska Native*, representing the spatial and cultural scope of legal harvesters; *Depleted,* the term referring to the ecological threshold at which Native hunters lose the right of withdrawal (although they may still be permitted to hunt); *Subsistence*, the activity as it relates to the scale of use; and *Authentic*, a term that delimits the scale of production of crafts. Below, I present the basis for interpretations; if and what scales are implicit in terms; and do these discourses contribute to 'fit,' or do they challenge attempts to manage resources like pagophilic pinnipeds?

Alaska Native

The MMPA does not define a coastally-residing Alaska Native, leaving USFWS and NMFS to provide definitions in their implementing regulations (50 CFR § 18.3 and 50 CFR Ch. II § 216.3, respectively), based on subjective categories of race (blood quantum), and ethnicity (tribal membership).

> *... a person defined in the Alaska Native Claims Settlement Act (43 U.S.C. section 1603(b) (85 Stat. 588)) as a citizen of the United States who is of one-fourth degree or more Alaska Indian (including Tsimshian Indians enrolled or not enrolled in the Metlaktla Indian Community), Eskimo, or Aleut blood, or combination thereof The term includes any Native, as so defined, either or both of whose adoptive parents are not Natives. It also includes, in the absence of proof of a minimum blood quantum, any citizen of the United States who is regarded as an Alaska Native by the Native village or town of which he claims to be a member and whose father or mother is (or, if deceased, was) regarded as Native by any Native village or Native town* [the term "Native Town" is replaced by "Native group" in the NMFS regulations]. *Any citizen enrolled by the Secretary pursuant to section 5 of the Alaska Native Claims Settlement Act shall be conclusively presumed to be an Alaskan Native for purposes of this part.*

The spatial scale of "Alaska Native" harvesters is defined by the political scale of Alaska. Neither USFWS nor NMFS specify the inland boundary of coastal residence. The spatial extent of potential harvesters authorized under the MMPA is limited to Alaska Natives who are United States citizens, and does not correspond to the spatial scale of harvesters, which includes neighboring Chukotka (Russia). The spatial boundary of resources is thus not matched with who the law defines as subjects.

Alaska Natives do not have to reside in the Native villages where they harvest marine mammals or trade in their products. Alaskan tribes cannot enforce regulations on non-members, so the jurisdiction of Alaska Native tribes to enforce local, State of Alaska, or National regulations (the three scales of American Federalism; Silvern, 1999) on non-members is not matched to the suite of potential hunters.

Temporally, ecosystem dynamics may also present some communities with opportunities to harvest marine mammals that are not regular or predictable in their subsistence harvests (such as result from new sea ice distributions). This presents further challenges in matching policy processes at the collective choice level with those at the scale of ecosystem processes and the operational level of individual hunters.

Depleted

Depleted, and in what context a population is depleted (with respect to an optimal sustainable population; OSP), like other similar legal terms (e.g., degradation) is "a hybrid blend of physical impacts, social framings and values that reflect the perspectives of more powerful groups" (Forsyth, 2001). The MMPA (16 U.S.C. 1362 § 3) defines "depletion" or "depleted" as where (a) *...a species or population stock is below its optimum sustainable population*, or (b) *a species or population stock is listed as an endangered species or a threatened species under the Endangered Species Act of 1973*. OSP in particular, involves *subjective value judgments that are* *not amenable to quantification on the basis of available data* (citing the Marine Mammal Commission; Bean and Rowland, 1997).

The political and logistic difficulties of counting pagophilic pinnipeds throughout their range are significant (Taylor et al., 2007). Furthermore, the Bering and Chukchi seas are undergoing rapid change due to warming and loss of sea ice, which is predicted to reduce overall populations of several of these species (Kelly, 2001; Robards et al., *submitted*). Thus, both spatial and temporal scales are significant challenges for the assessment of population status. The time required to legally establish depletion and subsequently respond in an effective manner results in what Fay (1979) described as "codified crisis management." That "depletion" is a fundamental tool in pagophilic pinniped policy under such difficult circumstances disconnects the fit of policy with practical management realities concerned with the fit of institutions and social and ecological conditions.

Discourses concerning depletion of pagophilic pinniped stocks are currently politically immaterial based on the inability to define stock structure and assess population status of these species (Taylor et al., 2007). However, even if research produces supportable population counts, the current rates of ecosystem change open up new subjective discourses over what these numbers mean in an ecosystem context. In contrast to ecosystem changes that are predicted to reduce pagophilic pinniped populations, economic value of some species has increased. Thus, a combined inability to assess Arctic pinniped populations, the predicted decline of their populations, and increased value of some species to Native communities can only support a mismatch between biophysical and socio-political systems.

Subsistence

The MMPA (§109(f)(2)) subjectively defines subsistence as:

> *the customary and traditional uses by rural Alaska residents of marine mammals for direct personal or family consumption as food, shelter, fuel, clothing,*

tools, or transportation; for the making and selling of handicraft articles out of nonedible byproducts of marine mammals taken for personal or family consumption; and for barter, or sharing for personal or family consumption.

The implementing regulations of USFWS and NMFS further define subsistence as the:

use by Alaskan Natives of marine mammals taken by Alaskan Natives for food, clothing, shelter, heating, transportation, and other uses necessary to maintain the life of the taker or for [the word 'for' is omitted by NMFS] *those who depend upon the taker to provide them with such subsistence.*

The definition of 'subsistence' has been controversial for decades, based on a suite of subjective interpretations. The appropriateness of subsistence has been based on values (traditional versus modern), racial (Native versus non-Native), social (urban versus rural), the balance between material and cultural components, and whether specific societal segments should be given exclusive or priority access to the harvest and use of natural resources (Morrow and Hensel, 1992; Schumann and Macinko, 2007).

Appropriate levels of subsistence have been defined ecologically, the ability of a stock to support a specific level of harvest; or socially, the perceived appropriateness of that harvest as 'subsistence.' For pagophilic pinnipeds, the Native exemption protects Alaska Natives from federal regulation prior to stock depletion resulting in a primary focus on controlling scale of use, rather than scale of harvest. Therefore, policy currently tries to fit subsistence with what is deemed appropriate at the spatial scale of coastally-residing Alaska Natives, and not necessarily with what is ecologically appropriate for pagophilic pinnipeds.

Subsistence restrictions on a species, particularly a primary species such as walrus will likely lead to increased harvests of alternative species such as seal to replace lost sustenance or economic benefits. Whales, walrus and seals represent different components of a mixed subsistence economy, intermixing with terrestrial species such as reindeer, store-bought foods, and federal aid (Krupnik, 1993; AHDR, 2004). If one component of the subsistence economy is less available due to political or seasonal restrictions in availability, others rise in importance. A focus on one component thus reduces the fit of management with the ecosystem-based goals of the MMPA, and illuminates the complications of dividing subsistence resources across jurisdictions (e.g., USFWS, NMFS, IWC).

Authenticity

The implementing regulations of USFWS (50 CFR § 18.3) subjectively define Authentic Native articles of handicrafts and clothing as those items that:

> *(a) are composed wholly or in some significant respect of natural materials and (b) are significantly altered from their natural form and are produced, decorated, or fashioned in the exercise of traditional native handicrafts without the use of pantographs, multiple carvers, or similar mass-copying devices. Improved methods of production utilizing modern implements such as sewing machines or modern techniques at a tannery registered pursuant to §18.23(c) may be used so long as no large-scale mass-production industry results. Traditional native handicrafts include, but are not limited to, weaving, carving, stitching, sewing, lacing, beading, drawing, and painting. The formation of traditional native groups, such as cooperatives, is permitted so long as no large-scale mass production results.*

NMFS provide a similar definition, although they include the need that Native articles of handicrafts and clothing are those that *were commonly produced on or before December 21, 1972.* Authenticity is thus, subjectively interpreted, and based on evaluations of a product's composition, degree of alteration, whether it is traditional, and the scale of production. "Significantly altered", "traditional", "mass production", and "large scale" are not further defined in either the MMPA, or its implementing regulations, but express subjective values about the appropriateness of capitalism and modernity in indigenous society. Alaska's USFWS Office of Law Enforcement (an operational level institution), suggests "significantly altered" is both "sufficiently/substantially from its natural form;" and work goes into improving the intrinsic value over the natural form (communication from Office of Law Enforcement to Dineega Specialty Furs on 10/11/07; on file with author). Thus, in this case, constitutional level rules are being interpreted at the operational level bypassing co-management, similar in nature to what Al Crane of USFWS Office of Law Enforcement described as "arbitrary prohibitions against people who are trying to maintain a self-sufficient lifestyle, but this is impossible if they abide by the law" (cited in Chambers, 1999: n120).

The use of marine mammal subsistence products for crafts for economic gain was intended by the U.S. Congress to protect an extant industry rather than encourage new enterprises. The U.S. Congress worried that expansion into new commercial endeavors would necessarily be accompanied by greatly increased harvests of marine mammals (Robards and Joly, 2008). Federal implementing regulations make some reference to the scale of activities: "formation of traditional native groups, such as cooperatives, is permitted so long as no large-scale mass production results." However, the scale of production within the U.S. Senate's original intent of supporting "cottage industries" but not initiating commercial ventures remains undefined.

Courts overruled the USFWS authority to regulate the harvests of non-depleted species because it broadened their regulator authority in a manner that the statute did not permit, thus implying that operational level harvest rights trump collective choice level management rights over the appropriateness of crafts (Robards and Joly, 2008). As a result, USFWS deleted the 1972 stipulation from their regulations in 2005 (although NMFS did not do likewise). This court ruling legally disconnects the biophysical scale of harvest from the social scale of use; thus "authenticity" provides little help in fitting institutions regulating social practices with pinniped or ecosystem considerations mandated by the MMPA. It also provides a poor fit with the needs of communities to adapt to their contemporary circumstances.

Failing to Effectively Co-Manage Pagophilic Pinnipeds

The basic solution to managing common-pool Arctic pinnipeds is to fit institutions (rights) with scales of social and ecological processes, limiting resource use in the interest of long-term sustainability (Acheson, 2006). Property rights must be effectively implemented to eliminate open-access, and resource-users must agree to rules curbing exploitation rates. Institutional failure occurs when one or both problems remain unsolved (Acheson, 2006), or the management context changes with no learning or adaption to the new conditions. Below I demonstrate the failures to (1) match the ecological scale of pagophilic pinnipeds with the socio-political scales of resource users; (2) monitor marine mammal populations and their ecosystems at temporal and spatial scales that allow management (in requirement 1) to be responsive to biotic and abotic change; and (3) ensure harvest levels are within the biological capacity of a species to sustain itself and its role in the ecosystem.

Failure to Unify Ecological and Sociopolitical Scales

My research indicates a collective action failure to implement rules matching spatial and temporal scales of ecosystem processes supporting Arctic pinniped populations with scales of social processes supporting Native communities. Pagophilic pinnipeds range widely, crossing jurisdictional boundaries between community and National jurisdictions. From a theoretical and practical perspective, current policy supports individual rights under largely open-access conditions within this range, while providing few incentives or the jurisdictional rights to encourage communities to implement and enforce local ordinances. Individuals and communities could act collectively, but must weigh the cost/benefits of other United States or Russian communities not complying because pinnipeds migrate between Russian and American waters.

The collective action failure to coordinate harvests throughout the range of pagophilic pinnipeds is exacerbated by the collective action failures at the global scale to address warming of the Arctic and loss of sea ice (ACIA, 2005). Elsewhere, attention to resource harvests that are within an agencies jurisdiction, rather than a focus on interplay with wider ecosystem scale issues has constrained co-management's effectiveness (Ebbin, 2002; Mansfield and Haas, 2006). Stoett (2002) goes further; suggesting habitat protection may be the only solution for natural resource problems characterized by hardened ideological positions regarding incompatible and incommensurable values.

Failure to Effectively Monitor Arctic Pinnipeds

When Native subsistence is framed in terms of resource conservation objectives, management challenges can be rendered technical and biological. Alternatively Native communities may construct the problem as one of access based on "images of who they are and their historical socio-cultural experience" (Armitage, 2008: 24). A net loss of Alaska Natives rights after a depletion finding (although subsistence may still be permitted) represents larger political struggles between Alaska Natives and the federal government over rights. Ecological unpredictability further curbs incentives for people to invest in stocks or reduce their own exploitation of a resource because of uncertainty that short-term restraint will result in long-term payoff (Acheson, 2006). Political uncertainties over the ramifications of a depletion finding on rights provide some political value to species not being found depleted.

The dearth of knowledge about population structure and status of Arctic pinnipeds (Taylor et al., 2007) mirrors the uncertainty described by Mansfield and Haas (2006), which contributed to subjective uses of scale supporting specific management interventions. Robards et al. (*submitted*) suggest an ecosystem-based approach supporting learning and adaptation to reflect (1) known ecological needs at specific scales, (2) observed conditions at those scales, and (3) predicted changes. An ecosystem monitoring program in the Arctic will require participation of communities who are more intimately involved with pagophilic pinnipeds than are most managers and scientists (Krupnik and Ray, 2007; Metcalf and Robards, 2008). However, full participation is unlikely without a meaningful Alaska Native role in problem definition and decision making such as for the Western Arctic Bowheads (*Balaena mysticetus*). Current discrepancies between harvest reporting programs and on-the-ground documented harvests for walrus confirm the inability to fit collective choice rules with those at the operational level for walrus co-management (Robards et al., *submitted*).

Failure to Match Scales of Utilization and Ecological Processes

Native take of non-depleted marine mammals is primarily controlled through the subjective goal of avoiding "wasteful" harvests (Robards and Joly, 2008). Other terms focus on subsequent use of harvested animals, rather than scale of harvest, providing little help in resolving scale mismatches between spatial and temporal scales of pagophilic pinniped ecology and subsistence needs (Young et al., 1994). Management focused on static conceptions of who Alaska Natives should be do not help fit dynamic social processes with the dynamic capacity of ecosystems to support them.

Subsistence is frequently conflated with food for survival, negating social and ideological aspects of the subsistence economy (Morrow and Hensel, 1992), or the problematic distinction between a mode of survival and one of profit (Schumann and Macinko, 2007). Discourses concerning level of subsistence better reflect efforts to fit specific values, rather than social realities or ecological capacity. Historical subsistence harvests were made above the survival level, providing insurance (rather than profit) for coming months and possibly years, based on uncertainty of future harvests (Krupnik, 1993). Mixed subsistence economies now depend on both cash and harvested products, encouraging acquisition of both to buffer future shortfalls. Post-Soviet Chukotka demonstrates the close connection between ecological and economic components of subsistence; the economic collapse of the Soviet system resulted in large-scale migrations of non-Natives out of Chukotka, and increased reliance on subsistence products by Native populations (Metcalf and Robards, 2008; Meek et al., *in press*).

Congress made the link between scale of economies and the scale of harvest, but in doing so reiterated the disempowering and pessimistic vision of the human prospect under Hardin's

"Tragedy of the Commons" scenario. This scenario has frequently been evoked to rationalize centralized government control and marginalization of indigenous communities, negating the role of common property institutions in resolving fit between ecosystem capacity and social needs (Ostrom et al., 1999). Alaska Natives have previously curbed exploitation rates based on their self-determined reasoning (Robards and Joly, 2008). Scholars have also demonstrated that commercial end uses in themselves, or improved harvest technology, do not necessarily lead to the degradation of resources; rather, these scholars argue that overexploitation may be due to the breakdown of key elements of traditional management practices and social relations (Young et al., 1994; Schumann and Macinko, 2007). Alternatively, degradation may be associated with migratory species, where the socio-political scale is mismatched with the range of a harvested species limiting discernable feedbacks between harvests and population health, which supports better utilizing the benefits of interplay in co-management (Berkes, 2005; Krupnik and Ray, 2007). Research in Alaska also suggests cash is shared within social networks scaled differently to those for material products (Magdanz et al., 2007), reiterating that contemporary social processes differ from historical, both in structure and scale, but perhaps not in function.

The Collective Choice Context of Operational Level Subsistence

The MMPA's 1972 promulgation was at a transition between Native "termination" policies that had existed since 1871, to ones supportive of self-determination (Nixon, 1970; Silvern, 1999). The MMPA's vague statute frames deliberative spaces of pagophilic pinniped co-management with subjective requirements reflecting Western beliefs and values about marine mammals, Alaska Natives, and the ecosystems they share. The "officializing strategies" (Bourdieu, 1977) that frame the deliberative space of co-management, and the subjective processes by which it is implemented through use of scale, set up a structure in which operational-level subsistence activities take place. This structure directly translates into material outcomes for ecosystems supporting marine mammals, managers, and subsistence hunters.

Alaska Natives and Alaska Senator Stevens established indigenous political power during the promulgation of the MMPA by framing rights as a unifying issue, rather than focusing on specific resource problems (see similar examples in Kuper, 2003; Li, 2002). Although gaining rights to harvest non-depleted marine mammals under the auspices of "traditional" need, the MMPA reduces temporal geographies of Native community relationships with marine mammals through static notions of subsistence and authenticity. The pattern of temporal limitations on Alaska Natives mirrors a "continuation of policies and attitudes aimed at assimilating [in this case, Alaska Natives] into the dominant political economy and culture (Silvern, 1999: 663). Native tribes were neither given constitutional or collective choice rights to reinterpret the discourses of co-management in a manner reflective of the implied cultural pluralism of Section 119. Therefore, collective choice level rules provide little legitimacy at the operational level, where diverse heterogeneous communities of hunters participate and adapt under rules written within a profoundly different milieu.

Through promulgating the MMPA, the U.S. Congress, and subsequently USFWS and NMFS, defined a political structure shaping Native subsistence, where transgressions from that structure are deemed illegal. Agencies now generate data to meet specific objectives (e.g., harvest monitoring) supporting the existing political structure. Native hunters and artisans are challenged to live within the law and self-determine their existence under a subjective political structure premised by static notions of tradition, when in fact global and inflationary pressures may exacerbate their dynamic realities (Schumann and Macinko, 2007). Under such circumstances, there are distinct benefits for individuals and groups isolated from the direct gaze and access of government officials – they can avoid rules deemed inconsistent with practical realities. Individual risk taking in favor of short term goals is favored by high transaction costs of monitoring and enforcement. Mismatches between stated goals of the MMPA and on-the-ground realities compromise the authority of current agency discourse to conserve marine mammals or support Alaska Native subsistence.

The legal codification of resources and people in equilibrium and simplistic (e.g., single species) models, rather than an acknowledgment of the complex adaptive interrelationships in human-environment systems, contributes to the failure of a wide array of natural resource regimes (Holling, 1986; Holling and Meffe, 1996; Folke et al., 2005; Cash et al., 2006). The power of privileged explanation and distortion of indigenous realities have been among the most common tools used by governments to oppress and control indigenous groups (Morrow and Hensel, 1992; Sardar, 1998; Harding, 2004; Nadasdy, 2003). The contemporary imposition of static ecosystem or cultural perspectives in policy may be regarded as hegemonic, where "strategies of ignorance and of knowledge production are central to the assertion of bureaucratic power and rationality" (Mathews, 2005: 797). Conversely, power and rationality of Alaska Natives in co-management may favor the same mechanisms to bolster their positions. For any community to comply with collective choice rules, its members must believe in the legitimacy of those rules, with legal requirements "embedded in moral discourses, which can be questioned, discussed, and changed" (Søreng, 2006: 151; drawing on Jürgen Habermas and Marcel Maus).

Where legal discourses impose restrictions, or disallow the self-replication of culture, humiliation may reflect conditions where self-determined practices of hunters and communities are deemed "futile, obsolete, and powerless" in the modern world (Robbins, 2005 drawing on Marshall Sahlins). Loss of cultural continuity under such political constraints is discordant with environmental justice, adaptation of rural communities, political economy and equity in co-management, or Native community health (Folke et al., 2005; Wexler, 2006; Plummer and

Armitage, 2007; Lovecraft, *In Press*). Poor compliance and participation in monitoring programs consequently limits the effectiveness of agencies, which, although able to accomplish mandated goals (monitoring populations and harvest), are unable to do so in a manner that informs legitimate management interventions.

A Pragmatic Approach to Achieving Conservation Objectives in Co-Management

The congressional level intent of the MMPA reflects the United States citizens' desire to conserve marine mammals and support Native subsistence. I have argued that decisions being made at the collective choice level by federal agencies are not conducive to these two goals. Institutions like co-management are technologies "seeking to create self-governing and responsible individuals (Triantafillou and Nielsen, 2001). If the political context of co-management does not foster such self-governance and responsible actions by hunters, we miss the point of co-management's role in conservation. I therefore suggest that the assessment of co-management should consider collective choice-level discourses concerning "fit", rather than just outcomes at the operational level. However, in order to do so, we need to "understand fully what forms of power led to those institutions that exist now, who their sponsors were, whose interests they have served, both originally and currently, and the potential losers and winners as a consequence of their reform" (Jentoft, 2006). Cultural politics and the signifying practices in which identities, social relations, rules and rights are contested may continually detract from natural resource oriented goals such as improving "fit" (Lee, 1993; Fischer, 2006). Without fit, co-management is unlikely to result in effective conservation, support subsistence as a way of relating to the world, or foster socially-desirable outcomes. I argue that in order to succeed in its natural resource-oriented objectives, co-management will need to encompass pluralistic values, while avoiding intransigence over those that are incompatible and incommensurable. Such a focus supports mutual solutions amenable to political, social, and ecological legitimacy, while reducing transaction costs through facilitating norm-based rather than rule-based local practices (Jentoft, 2000; Cash et al., 2006; Cumming et al., 2006).

Conclusions

Co-management of Alaska's Arctic pinnipeds exists within a preexisting political context hindering the attainment of the MMPA's goals. Institutions designed to conserve marine mammals and support Alaska Native subsistence do not fit social and ecosystem processes in a manner conducive to healthy marine mammal populations and subsistence communities. These hindrances result from specific interpretations, rather than statutory requirements of the MMPA. The collective choice level institution of co-management could support co-construction of the terms governing Native subsistence, supporting a more pluralistic deliberative space (see also Aufrecht, 1999; Nursey-Bray, 2006). International pluralistic agreements provide models demonstrating benefits of unifying biophysical ranges of marine mammals and socio-political scales of governance; they also provide opportunities for learning; and help remote communities adapt to meet contemporary conditions in a self-determined manner (Young, 2005; Meek et al., *in press*).

Integrating local, community, and global scales of human concern and valuation requires policy that accomplishes goals at multiple scales. Problems necessitate finding tangency across incompatible and potentially incommensurable sets of values separating groups of people. Resolving fit between scales of ecosystem and social processes in mutually beneficial manners may offer such tangency, but will always be dynamic and contested. In order to adaptively achieve conservation goals, co-management partners may need to revisit what is the best available science, and dispel the assumptions inherent in current policy that are discordant with achieving both conservation and subsistence goals. In this manner, deliberative spaces may be produced that support governance in the context of both mutual desires and incompatible and incommensurable values.

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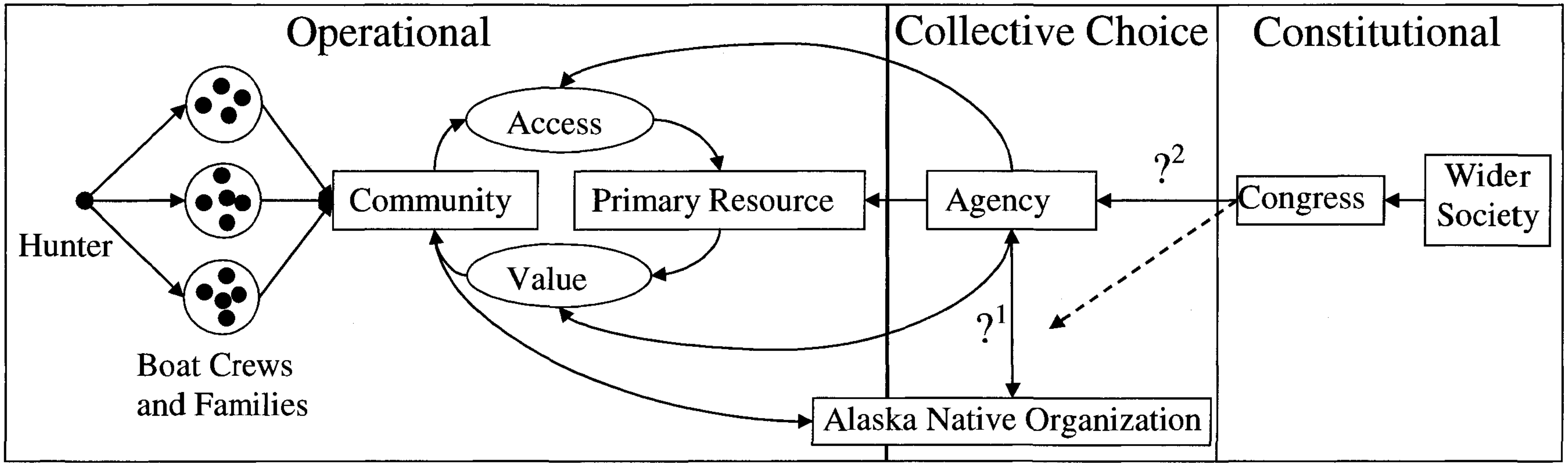

Figure 3-1. Conceptualization of marine mammal co-management in Alaska using the Institutional Analysis and Development (IAD) Framework (Ostrom, 2007). Question mark 1 represents the negotiated co-management relationship between a federal agency and an Alaska Native Organization. Question mark 2 represents the contested views as to the discretionary authority that agencies should have to interpret policy (Spicer and Terry, 2006). The dashed arrow represents the location of my primary argument; that Congressional rules need to be co-interpreted by both federal agencies and Native representatives for successful co-management that is relevant to communities. I build from Fischer (2006) to argue that unless pluralistic interpretations are allowed of laws under which co-management operates (balancing conservation and development objectives) it is unlikely that statutory conservation goals will be accomplished.

CONCLUSIONS

My primary question in this dissertation was "what are the effects of a changing climate on the human-walrus relationship." I began in Chapter 1 by investigating the effect of changing climatic regimes on the adaptation of Alaska Native subsistence walrus hunting. In Chapter 2, I moved to the ability of policy governing the human-walrus relationship to adapt to changing environmental conditions. Finally, in Chapter 3, I considered the ability of Alaska Native marine mammal subsistence hunters and Pacific walrus to adapt to climatically-induced environmental change under current policy interpretations. I summarize my findings from these chapters below.

Changes in the Arctic climate have resulted in a general decline in both the availability and vitality of sea-ice in the Bering Sea. Changes in sea-ice conditions have direct bearing on ice-associated species such as Pacific walrus (*Odobenus rosmarus divergens*). In conjunction with the recent changes in environmental regimes, I find markedly different magnitudes and degrees of variability in success and timing of spring walrus hunts at the Native villages of Diomede, Gambell, and Savoonga. Local weather and ocean currents, along with socio-political factors promote strong inter-annual variability in the timing and size of walrus harvests at all villages. However, longer-term climatically-controlled regime shifts are also evident in the seasonality and success of walrus hunting at Diomede, Gambell, and Savoonga. Deterioration of sea-ice conditions has reduced the window of hunting at Diomede as walrus migrate north more rapidly; the same deterioration of sea-ice has improved Savoonga's access to walrus. The size of the harvest has declined dramatically at Diomede during the last two decades; however, my data suggest that this is due to circumstances beyond the climatic conditions I investigate. Politics, changing social conditions and new management regimes have all had profound impacts on access to, and value of walrus to communities since 1952. Together, these factors mediate the ability of walrus and communities to adapt and transform to better fit with a changing environment.

My review of walrus management suggests that to proactively monitor and respond to expected changes in the walrus ecosystem, management should use scientific criteria that depend less on the necessity of detecting numerical depletion than on precautionary actions based on known ecological needs and observed ecological changes. Even considering that carrying capacity is spatially and temporally transient, an "ecological indicators" approach, if decision rules can be developed, may better align immediate management needs with the best available scientific information. This approach might avoid the crises that have befallen several other marine mammal species, where populations were allowed to erode while waiting for legally defensible evidence of population depletion. The application of new approaches such as adaptive co-management, using a suite of ecological and population indicators, has theoretical promise for making management responsive to observed ecosystem and population changes.

Despite the potential advantages of governance methods such as co-management, trust in fostering a solution between Alaska Natives and the federal government is eroding. Law enforcement's capacity to enforce the MMPA in these remote communities is tenuous, compliance is low, and current regulations provide minimal incentive to comply (Robards and Joly, 2008). Thirty years have passed since any substantive walrus harvest management took place in Alaska, so young hunters have no experience with formal harvest constraints. Changing ecological conditions that may significantly impact walrus, and continued increases in the importance of cash in remote communities, collectively make solutions that are mutually agreeable to conservation interests and Native communities essential.

To illuminate constraints on improving the ability of policy to respond to a changing environment, I return to the MMPA's goals of balancing the conservation of marine mammals with the protection of Alaska Native subsistence rights. I propose that a logical goal of management under the MMPA would be to foster the "fit" between policy and the scale of walrus ecosystems and social needs. However, the MMPA has been interpreted in a manner that is premised on static value-laden notions of ecosystems and Alaska Native subsistence communities, thus precluding "fit." These legal interpretations provide significant constraints on the ability of managers to provide conditions conducive to accomplishing the shared goal of conserving Pacific walrus – in this case "fit."

I build from prior work (Robards and Joly, 2008) to argue that accomplishing the goal of "fit" could be accomplished using the best scientific evidence, an attitude of pluralism, consideration of actual contemporary conditions, and support of incentives for mutually beneficial outcomes between communities (e.g., fostering community resilience and a continuing relationship with walrus), the government (e.g., conservation of walrus), and other parties (e.g., environmental groups). To do so however, walrus subsistence governance will need to focus more on a legitimate pluralistic process, than the current focus on value-laden interpretations of the MMPA's statute.

Restating the problem of subsistence management, which is currently largely characterized as a problem of details, to one that takes a broader view of walrus and community health has the potential to cultivate working relationships between parties. It also has the potential to promote hunter and community pride in accomplishing the harvest in a manner that is mutually agreed upon, rather than the current situation that neither fosters walrus populations nor Alaska Native communities (Robards and Joly, 2008). However, formalized co-management under the MMPA starting in 1994 did not support new pluralistic interpretations of the statute, or foster convergence between law, management, walrus ecology, and Alaska Native subsistence priorities. Repercussion of not fostering better relationships in natural resource management in a manner that benefits health and adaptation of communities can only be speculative. However, the consequences of negating the legitimacy of laws in remote environments has often affected renewable resources and communities more severely than if efforts had been made to find mutually agreeable options (Agrawal, 2005; Reeves, 2002; Marsh et al., 2003; Brosius et al., 2005; Robards and Greenberg, 2007).

In considering my question of how a changing climate will impact the human-walrus relationship, I conclude that the resilience of policy may challenge the resilience of the human-walrus subsistence relationship more than the impacts of a changing climate (see also Armitage, 2008). By considering my question broadly, as an archaeology of knowledge, I illuminated the emergent nature of population and harvest numbers (Figure 2-1), and demonstrated how management based on these two emergent phenomena is an inadequate model to foster resilience of communities and wildlife populations. Philosophically, I framed my dissertation in works by George Perkins Marsh, Gifford Pinchot, John Muir, and Aldo Leopold. The complexities of managing ecosystems and the existence of incompatibility and incommensurability values (such as conservation versus preservation) considered by these icons of environmental thought still challenge us today. Improving management in a manner that fosters both resilient walrus populations and Alaska Native coastal communities will require serious and simultaneous commitments toward pluralistic goals at local, national, and international levels, and significant investments in time, money, and political will.

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APPENDIX

Related Publications

Chapin, F.S., A.L. Lovecraft, E.S. Zavaleta, J. Nelson, M.D. **Robards**, G.P. Kofinas, S.F. Trainor, G. Peterson, H.P. Huntington, and R.L. Naylor. 2006. Policy strategies to address sustainability of Alaskan boreal forests in response to a directionally changing climate. *Proceedings of the National Academy of Sciences of the USA (PNAS)* 103: 16637-16643.

Chapin, F.S., M.D. **Robards**, H.P. Huntington, J.F. Johnstone, S.F. Trainor, G.P. Kofinas, R.W. Ruess, N. Fresco, D.C. Natcher, and R.L. Naylor. 2006. Directional changes in ecological communities and social-ecological systems: A framework for prediction based on Alaskan examples. *American Naturalist* 168: S36-S49.

Meek, C.L., A.L. Lovecraft, M.D. **Robards**, and G.P. Kofinas. *In press*. Building resilience through interlocal relations: case studies of walrus and polar bear management in the Bering Strait. *Marine Policy*

Metcalf, V. and M.D. **Robards**. 2008. Sustaining a healthy human-walrus relationship in a dynamic environment: Challenges for comanagement. *Ecological Applications* 18(2): S148-S156.

Robards, M.D., and J.A. Greenberg. 2007. Global constraints on rural fishing communities: Whose resilience is it anyway? *Fish and Fisheries* 8: 14-30.

Robards, M.D., and J.L. Joly. 2008. Interpretation of 'wasteful manner' within the Marine Mammal Protection Act and its role in management of the Pacific walrus. *Ocean and Coastal Law Journal* 13(2): 171-232.